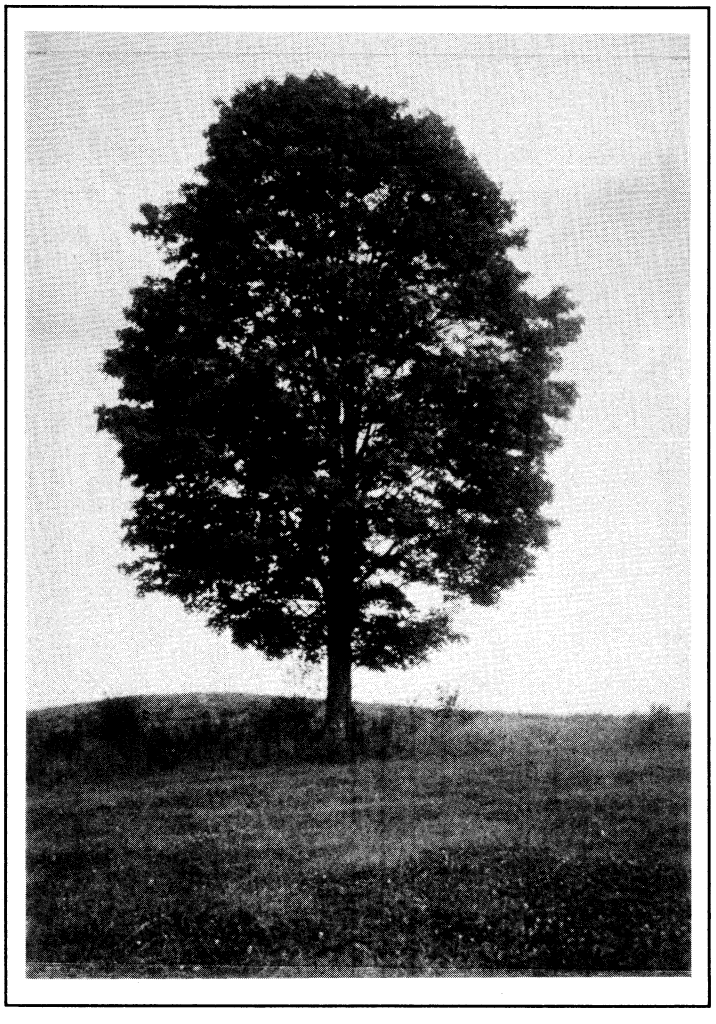
HEALTH AND PRODUCTIVITY OF VERMONT'S FORESTS 1991

H. Brenton Teillon

and

Sandra H. Wilmot



Vermont Department of Forests, Parks and Recreation
103 South Main Street
Waterbury, Vermont 05671

May 1993

Acknowledgements:

Thanks to the staff of the Vermont Forestry Division for their dedication in gathering the information used in this document.

Other information was received from the Air Pollution Control Division, the Water Quality Division, the Department of Fish and Wildlife, the Green Mountain Club, the Vermont Department of Agriculture, Food and Markets, the USDA Forest Service and the North American Maple Project.

Editing and stylistic assistance was graciously given by Ginger Anderson, Barbara Burns, Robert De Geus, Ronald Kelley, Brian MacDonald, and David Stevens. The cover and document layout were diligently provided by Cheryl Abare.

The USDA Forest Service, State and Private Forestry, Forest Health Protection staff provided support and partial funding for this effort.

This document is available upon request in large print, braille and audio cassette.
VT TDD Relay 1 (800)-253-0191

TABLE OF CONTENTS

INTRODUCTION — 1
VERMONT'S FOREST RESOURCE — 2
METHODS USED TO ASSESS FOREST HEALTH — 6
GENERAL FACTORS AFFECTING FORESTS
- WEATHER IN 1991 — 8
- AIR QUALITY — 8
  - Acid Precipitation — 8
  - Ozone — 10
- FOREST INSECT AND DISEASE PESTS — 11
- FOREST AND WILDLAND FIRES — 11

TYPES OF FORESTS IN VERMONT — 11
- Northern Hardwood Forest Type Group — 13
  - *MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH*
    - Sugar Maple — 13
    - American Beech — 17
    - Yellow Birch — 20
    - Red Maple — 22
    - White Ash — 25
- Spruce/Fir Forest Type Group — 28
  - *MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH*
    - Balsam Fir — 28
    - Red Spruce — 30
- White/Red Pine Forest Type Group — 32
  - *MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH*
    - White Pine — 32
    - Hemlock — 34
- Aspen/Birch — 35
  - *MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH*
    - Paper Birch — 35
- Oak/Hickory Forest Type Group — 37
  - *MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH*
    - Oak — 37

SUMMARY — 39
ENDNOTES REFERENCED IN TEXT — 40
REFERENCES CITED — 41
ABBREVIATIONS — 42
APPENDIX A — 43
- PLOT LOCATIONS AND PROGRAM DESCRIPTIONS
  - NORTH AMERICAN MAPLE PROJECT
  - NATIONAL FOREST HEALTH MONITORING
  - VERMONT HARDWOOD TREE HEALTH SURVEY
  - VERMONT MONITORING COOPERATIVE
  - AERIAL SURVEY PROCEDURE

APPENDIX B — 44
- REGIONAL COMPARED WITH VERMONT FOREST HEALTH RESULTS FOR EACH SPECIES

LIST OF FIGURES

Figure 1. Sawtimber Species Composition
Figure 2. Growing Stock Composition
Figure 3. Sawlogs Harvested in 1991
Figure 4. Pulpwood Harvested in 1991
Figure 5. Value from 1991 Harvest
Figure 6. Forest Type Groups in Vermont
Figure 7. Sugar Maple Sawtimber Log Grades, 1983
Figure 8. Health of Vermont's Sugar Maple (NAMP, VHTHS, NFHM)
Figure 9. Trend in Condition of Vermont's Sugar Maple (NAMP)
Figure 10. Trend in Condition of Vermont's Sugar Maple (NFHM)
Figure 11. Beech Sawtimber Log Grades, 1983
Figure 12. Health of Beech, Oak, Paper Birch and Yellow Birch (VHTHS)
Figure 13. Mortality of Beech, Oak, Paper Birch, Yellow Birch and Red Maple (VHTHS)
Figure 14. Yellow Birch Sawtimber Log Grades, 1983
Figure 15. Trend in Condition of Yellow Birch in Essex County
Figure 16. Red Maple Sawtimber Log Grades, 1983
Figure 17. Health of Vermont's Red Maple (VHTHS, NFHM)
Figure 18. Trend in Condition of Vermont's Red Maple (NFHM)
Figure 19. White Ash Sawtimber Log Grades, 1983
Figure 20. Health of Vermont's White Ash (VHTHS, NAMP)
Figure 21. Trend in Condition of Vermont's White Ash (NAMP)
Figure 22. Health of Vermont's Balsam Fir, Red Spruce and White Pine (NFHM)
Figure 23. Trend in Condition of Vermont's Balsam Fir (NFHM)
Figure 24. Trend in Condition of Vermont's Red Spruce (NFHM)
Figure 25. White Pine Sawtimber Log Grades, 1983
Figure 26. Trend in Condition of Vermont's White Pine (NFHM)
Figure 27. Paper Birch Sawtimber Log Grades, 1983
Figure 28. Red Oak Sawtimber Log Grades, 1983
Figure 29. White Oak Sawtimber Log Grades, 1983

LIST OF TABLES

Table 1. 1991 Ozone Levels in Vermont.

LIST OF MAPS

Map 1. Vermont Acid Precipitation Monitoring Program Sites and Mean pH Values, 1983 through 1991.

INTRODUCTION

This is the first annual report summarizing information on the health and productivity of Vermont's forests. It includes facts on our forests that will be of interest to forest landowners, forest managers, forest product industries, sugarmakers, scientists, legislators, educators and the general public.

The information presented consists of data collected by the Department of Forests, Parks and Recreation, as well as a compilation of data collected by others, all relating to Vermont's forests.

There are many different ways to define the health and productivity of forests, depending on the values and uses assigned to them. They can mean abundance of wildlife habitat, aesthetic sustainability for recreation or tourism, maintenance of biodiversity, high quality timber production, etc.

For the purposes of this report, we deal with forest health in terms of trees. Good tree health means forests aesthetically pleasing, capable of maintaining a diversity of plant species and with the potential to provide resources to landowners. The productivity of our forests is addressed in terms of the growth and abundance of our forested resource and the diversity of products we derive from them.

For more information on the health and productivity of Vermont's forests, contact the Department of Forests, Parks and Recreation, 103 South Main Street, Waterbury, VT 05671-0602, (802)-241-3678.

VERMONT'S FOREST RESOURCE

Forests comprise three-quarters of Vermont's land mass (4.5 million acres of forested land). Most of this forest land is classified as appropriate for commercial forest use (4.4 million acres). But forest land use varies considerably, since 90% of these commercial forests are privately owned (Frieswyk and Malley, 1985) and subject to the management desires and attitudes of each individual landowner.

Our forests are aging or increasing in maturity. The amount of sawtimber increases annually. The estimated volume of sawtimber in Vermont is 14.0 billion board feet, an average of 3,163 board feet per acre, as determined during our last statewide forest inventory in 1983.[1] Wood quality has improved over previous years, with Grade 1 sawlogs accounting for 5.6% of pine sawtimber, and 11.2% of hardwood sawtimber (Frieswyk and Malley, 1985).[2]

Despite our aging forests, there is an abundance of younger trees. Growing stock volume is estimated at 6.3 billion board feet, or 1,419 cubic feet per acre (Frieswyk and Malley, 1985).

The three most abundant tree species of sawtimber size (based on volume) are sugar maple, hemlock and white pine (Figure 1) (Frieswyk and Malley, 1985).

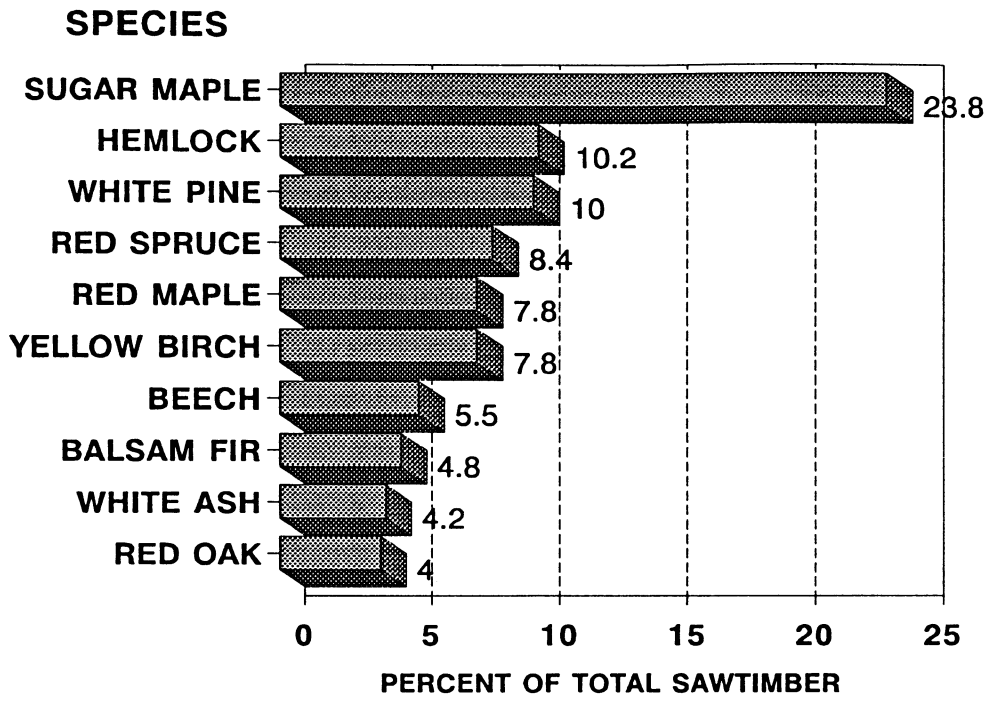
The three most abundant tree species in growing stock volume are sugar maple, red maple and hemlock (Figure 2) (Frieswyk and Malley, 1985).

The volume of sawlogs and veneer logs harvested in 1991 was 249,728,000 board feet, with spruce/fir and white pine comprising 58% of harvested logs (Figure 3). Export of sawlogs and veneer to other states and countries totaled 88,694,000 board feet. Pulpwood volume harvested was 330,897 cords, with spruce/fir and hemlock comprising 59% of harvested material (Figure 4) (Dept. of Forests, Parks and Recreation, 1991a).

The value of the 1991 harvest is over $80 million, based on estimated values delivered to the mills. Spruce/fir, white pine and sugar maple contributed over half of this value (Figure 5) (Dept. of Forests, Parks and Recreation, 1991a).

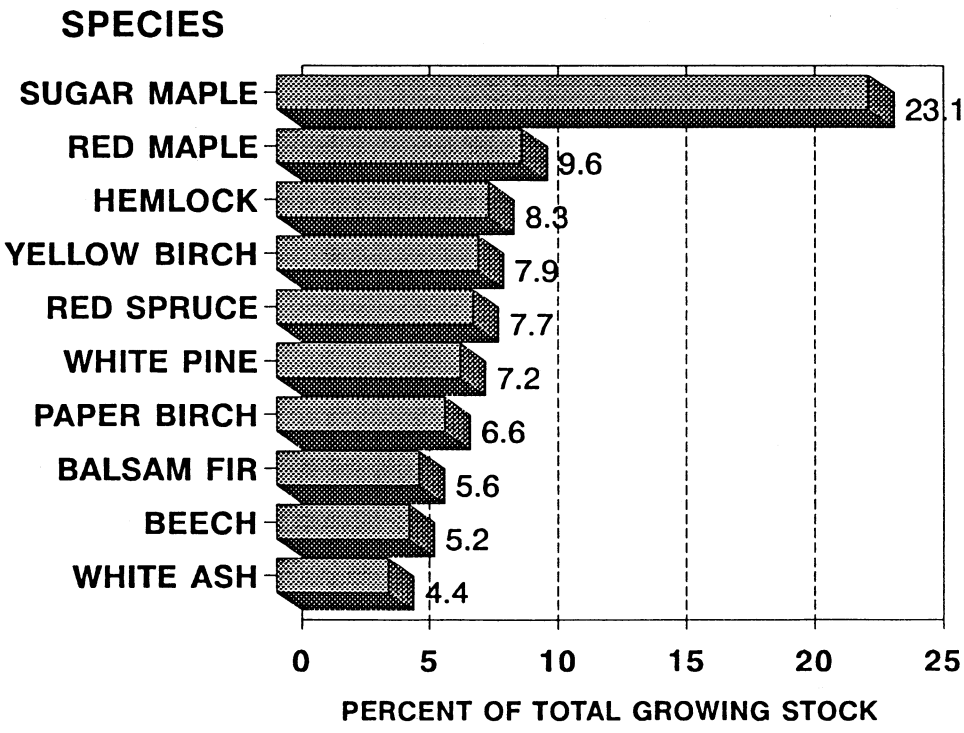
Aesthetic values derived from forests are difficult to quantify. However, <u>without</u> forests, revenues from fall foliage tourism estimated at $75 million annually (based on historical data provided by the Vermont Travel Division), recreational use for hiking (estimated by the Green Mountain Club at 100,000 hikers annually), and hunting uses ($5.02 million in 1991 revenues from 267,000 hunters) (Dept. of Fish and Wildlife, 1991) would be much reduced.

Another use of Vermont's forests, that of maple syrup production, brings $10-13 million to Vermont's economy annually (Vermont Dept. of Agriculture Food and Market, 1991). For 1991, 440,000 gallons of syrup was produced, with a value of $12.54 million. Along with the revenues generated from this forest resource, are the cultural traditions and values of forests associated with maple sugaring.



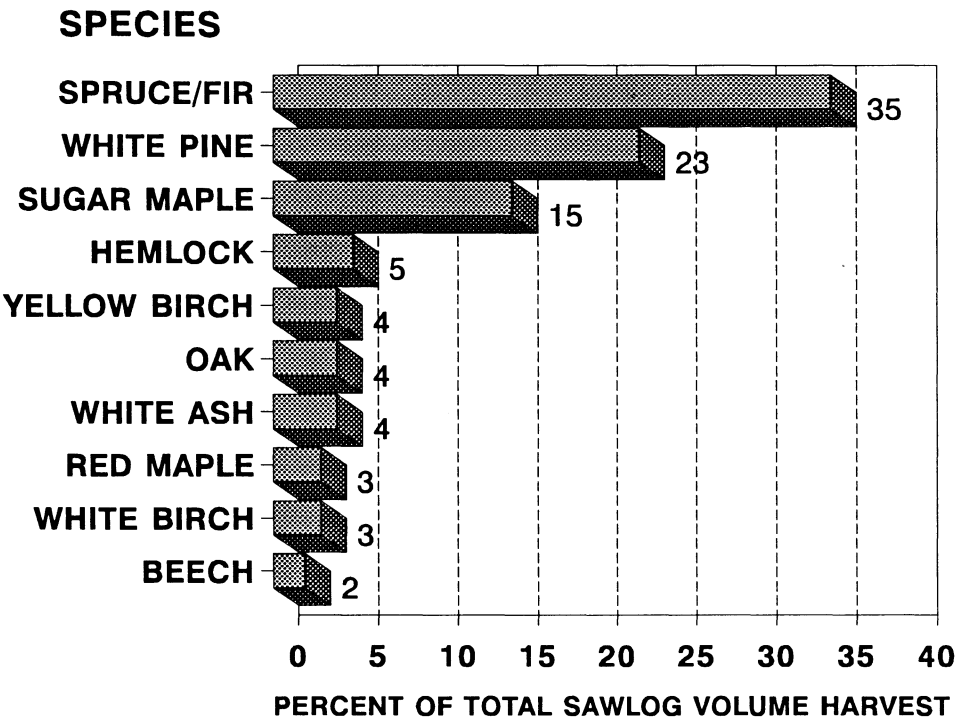
From: Frieswyk & Malley, 1985

Figure 1. Sawtimber Species Composition. The 10 most abundant tree species (percent, based on a total volume of 14.0 billion board feet) of sawtimber size trees in Vermont forests.



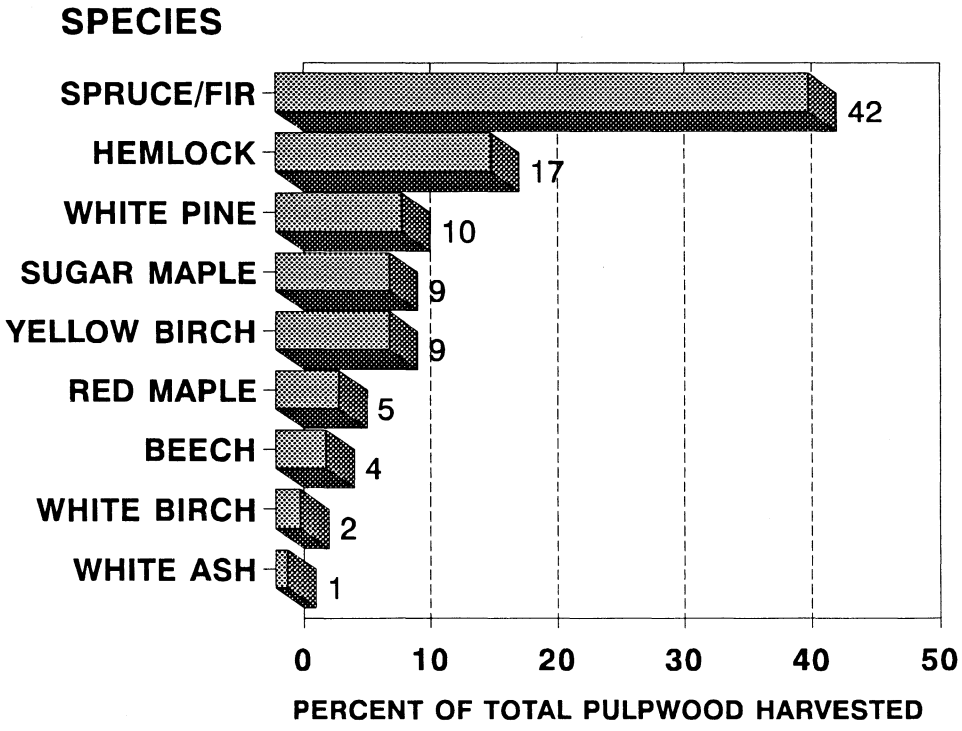
From: Frieswyk & Malley, 1985

Figure 2. Growing Stock Species Composition. The 10 most abundant tree species (percent, based on a total volume of 6.3 billion board feet volume) of growing stock size trees in Vermont forests.



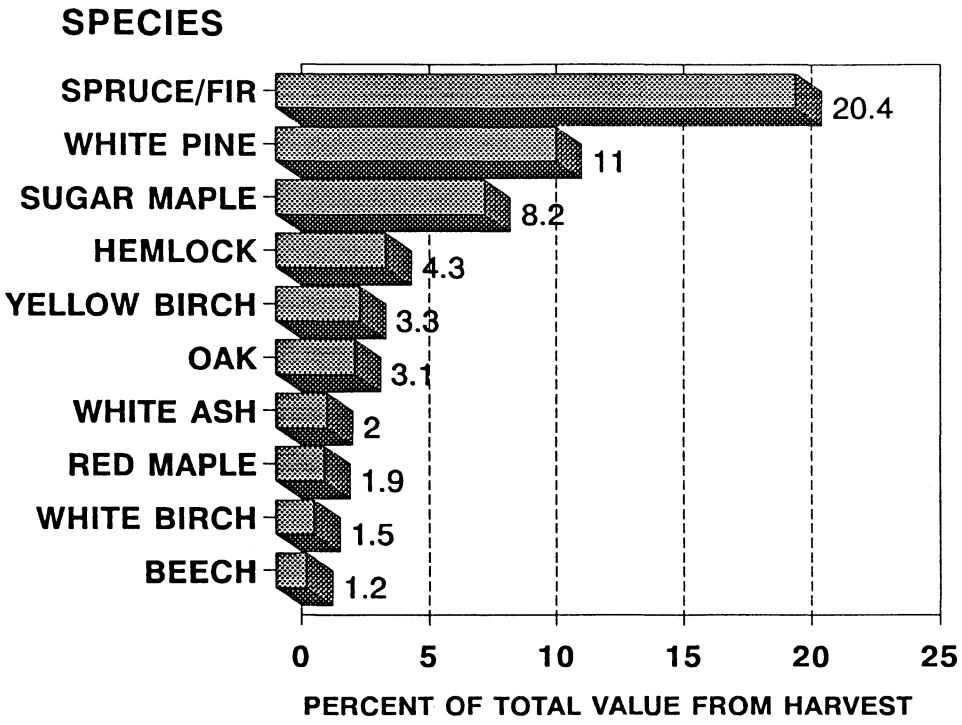
Vt. Dept. Forests, Parks & Recr. 1991a

Figure 3. Sawlog Volume Harvested in 1991. The percentage of the 1991 sawlog harvest in Vermont represented by individual tree species or groups (as in spruce/fir, where species are not separated). Based on a total harvest of 249,728 ,000 board feet in 1991.



Vt Dept. Forests, Parks & Recr. 1991a

Figure 4. Pulpwood Harvested in 1991. The percentage of the 1991 pulpwood harvest in Vermont represented by individual tree species or group (as in spruce/fir, where species are not separated). Based on a total harvest of 330,897 cords in 1991.



Vt Dept. Forests, Parks & Recr. 1991a

Figure 5. Value from 1991 Harvest. The value contributed by individual tree species to the 1991 harvest, expressed as a percentage of the total value of $80 million. Values are based on prices delivered to mills.

METHODS USED TO ASSESS FOREST HEALTH

Three major forest health programs are conducted in Vermont to assess the condition of trees on permanent plots located throughout the state: the Vermont Hardwood Tree Health Survey (VHTHS), the North American Maple Project (NAMP) and the National Forest Health Monitoring Program (NFHM) (see Appendix A).

The VHTHS was established in 1985, with the first year of ground evaluations in 1986. It is repeated every 5 years. The results from this survey are representative of the hardwood resource in Vermont.

The North American Maple Project (NAMP) began in 1988 and is conducted annually. This program was established as a regional program, and includes plots in 7 states and 4 Canadian provinces. The 29 Vermont plots (chosen to represent the range in maple condition) are analyzed alone for this report.

The National Forest Health Monitoring Program (NFHM) began in 1990. Again, this is a regional program that includes all the New England states and is expanding to become a national program.

The 24 Vermont plots are analyzed separately for information on Vermont tree conditions used in this report.

We have determined forest health by: 1.) annually assessing tree crown conditions (dieback, density of foliage, etc.), 2.) periodically measuring tree growth, and 3.) annually assessing mortality.

Other indicators of forest health measured are: abundance, condition and type of regeneration; stand structure and size classes; site characteristics, such as soils, elevation, slope, aspect, understory vegetation, etc.; and signs and symptoms of damage to trees. The latter information is useful in determining the cause for any decline in tree condition.

In each of the three surveys described above, trees are permanently marked and measured each survey year. This allows us to compare tree health over time. Each program uses a similar system to measure tree health, but contains slightly different categories for rating trees and for determining which trees are healthy. We have used the term "healthy" to indicate trees with less than a given amount of dieback (twigs and branches dying back from the tips). The amount or degree of crown dieback is believed to express the response of trees to stresses like drought or insect defoliation. Conversely, lack of dieback reflects good growing conditions and lack of stress on trees.

At this point in time, crown dieback is the measurement that we know the most about, and can most reliably be used to evaluate tree health. Other measurements are useful for establishing trends over time, and in the future may be more reliable as predictors of health or decline.

The definitions of healthy used in each program are as follows:

PROGRAM	ESTIMATED DIEBACK AMOUNT	HEALTH CATEGORY
VHTHS	less than or equal to 10% crown dieback	Healthy
NAMP	less than or equal to 15% crown dieback	Healthy
NFHM	less than or equal to 20% crown dieback	Healthy

Differences in annual crown ratings between programs may be attributed to each program's definition of healthy.

Mortality under each forest health program is reported in different ways, so are not easily comparable. VHTHS reports new and old mortality (excluding snags) on dominant and codominant trees. NAMP initially reported all standing dead trees greater than or equal to 5" at DBH. In subsequent years (1989 through 1991) new mortality on dominant and codominant trees was reported. The NFHM initially reported all standing dead trees in the same manner as the NAMP. In subsequent years under this program new mortality was reported for all trees greater than 5 inches in diameter.

In addition to forest health plots, aerial surveys are conducted each year to determine damage to forests from insects, diseases, weather or man's activities. Detection of such forest stresses helps determine possible causes for unhealthy trees, for both the current year and into the future. Results are published annually in the "Forest Insect and Disease Conditions in Vermont" by the Department of Forests, Parks and Recreation which is available to the public (Vt. Dept. Forests, Parks and Recreation, 1991c).

GENERAL FACTORS AFFECTING FORESTS

WEATHER IN 1991

Weather is probably the most important stress agent of our trees and forests. Drought, cold-open winters and other weather extremes have historically been responsible for many of our major forest declines.

In 1991, spring weather was conducive to early tree growth, warm with plenty of moisture, resulting in the development of lush foliage.

A late spring frost, however, caused some damage to those tree species whose leaves come out later in spring (butternut, white oak and new growth on Christmas trees) and hadn't hardened off.

The overall growing season was warmer than normal, with average rainfall that provided adequate conditions for tree growth. June and July, however, brought little precipitation, and water tables dropped considerably by mid-summer. These conditions led to leaf scorch of hardwoods, especially noticeable in the Northeast Kingdom (Essex, Orleans and Caledonia Counties) where 55,600 acres of symptomatic trees were observed. Additional adverse effects of these dry conditions on trees may show up over the next couple of years, especially on generally wet or dry sites where roots are shallow.

August, in contrast to June and July, was wetter than normal, so water tables were replenished for the winter. In general, weather conditions favored tree growth in 1991.

AIR QUALITY FOR 1991

Acid Precipitation

There are many hypotheses developed on how acid precipitation or "acid rain" may be affecting our forests. It may affect foliage directly causing a variety of responses by plants, or it may leach into the soils, affecting nutrient availability or other soil functions.

Many studies are ongoing to address the implications to forests from acidic deposition (see STRESSES TO RED SPRUCE IN 1991, page 30 for more information on results).

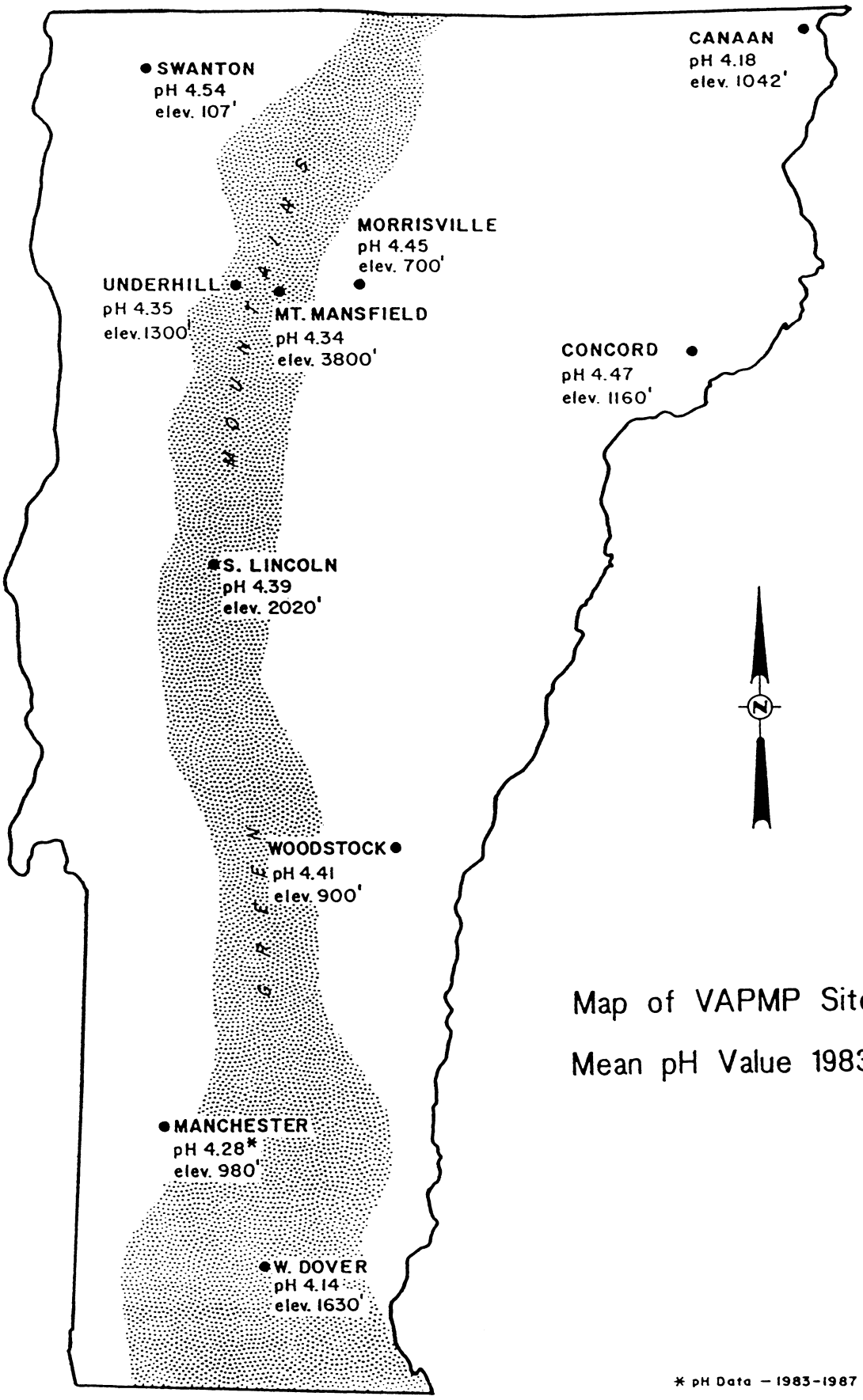
One simplistic method for determining "acid rain" (acidic precipitation) is to measure the pH of precipitation, since precipitation is changed by particles in the air, therefore reflecting the amount of acid-forming pollutants present. There are 10 sites in Vermont where the pH of precipitation has been monitored since 1983 (Map 1).

For comparative purposes, "clean water" (distilled water) has a pH of 5.6. The average pH for all sites in 1991 was 4.47. Although this is slightly higher (less acidic) than in other years, there is high variability in the pH even at one site, so a higher annual pH may not mean a long-term trend towards less acidic precipitation. More time is needed to assess whether these measurements truly indicate a trend towards cleaner air (Dept. of Environmental Conservation, 1992).

Average pH of precipitation varies slightly between the Vermont sites, ranging from pH 4.14 in West Dover to pH 4.54 in Swanton (Map 1). How soils handle or buffer against acid precipitation can vary depending on local soil and rock characteristics.

Soil acidity is important to forests, since it determines where each tree species will grow and may be a factor in tree health.

Map 1. Vermont Acid Precipitation Monitoring Program (VAPMP) sites and mean pH values, 1983-1991. →



Map of VAPMP Sites and Mean pH Value 1983 - 1991

* pH Data — 1983-1987

Ozone

Ozone may be an important stressor affecting the long-term health of Vermont's forests. Ozone is a gas that enters plant cells through normal growth processes, where it can cause cell death, and reduced growth and vigor.

Despite a common belief that ozone levels are higher in urban and roadside settings, ozone is not confined to these areas. Symptoms of foliage damage from high ozone levels have been observed in remote areas such as the Lye Brook Wilderness Area in southern Vermont (O'Brien, 1990 & 1991), and Mount Mansfield in northern Vermont (Dept. of Forests, Parks and Recreation, 1991b).

There was one exceedance of the National Ambient Air Quality Standard for ozone (the level established for protection of human health, 120 ppb for 1 hour) in 1991, and additional hours with levels damaging to sensitive plants were recorded.

The figures presented (Table 1) show the number of hours during the growing season when levels were 60 ppb or higher (affecting some sensitive plant species) or 80 ppb or higher (affecting most sensitive plant species). "Episodes" reflect the number of times during the growing season when trees were exposed to long periods of high ozone levels.

Large areas of trees damaged by high ozone levels have not been detected in Vermont.

At this time it is not known what the total impact from ozone is to our forests.

Tree species known to be sensitive to ozone include: black cherry, red maple, quaking aspen, white ash, yellow birch and sycamore (Dowsett et al, 1991).

In 1991, symptoms of ozone damage were recorded from milkweed and black cherry seedlings (two particularly sensitive plant species) at a site in Underhill. Air quality and forest health programs in Vermont are continually improving our monitoring efforts of this potentially important stress agent.

Table 1. A summary of ozone levels for 1991 from 2 Vermont Air Pollution Control Monitoring Sites[1].

Monitor site	Total # hours with ≥ 60 ppb	≥ 80 ppb	Maximum level[2] ppb	Date	# of Episodes[3]
Underhill	366	42	93	5/24	3
Bennington	419	104	126	8/17	6

1. Data provided by the Vermont Air Pollution Control Division.
2. Maximum recorded in a single hour.
3. "Episodes" are two consecutive days when ozone exceeds 80 ppb for at least 2 hours.

FOREST INSECT AND DISEASE PESTS

Forest insects and diseases play a major role in forest health. Historically, major declines have been attributed to insects, diseases or a combination of the two. Many of the major pests have been introduced from other countries, so have limited natural control agents, and have become problems of our forests as a result.

Forest insect populations are typically cyclical (Parker et al, 1989). Low populations are maintained for numerous years, where no visible defoliation or damage to trees can be observed. Favorable environmental conditions allow populations to increase to outbreak levels, resulting in localized or widespread defoliation of forest trees.

Numerous years of defoliation can be detrimental to trees, especially when combined with other stress factors. Managing forests to reduce pest populations and additional stresses during high pest population years can help avoid serious impacts to our trees.

Although a thorough coverage of forest insect and disease pests is not possible in this report we do present specific information on pests of major concern for 1991 under each individual tree species.

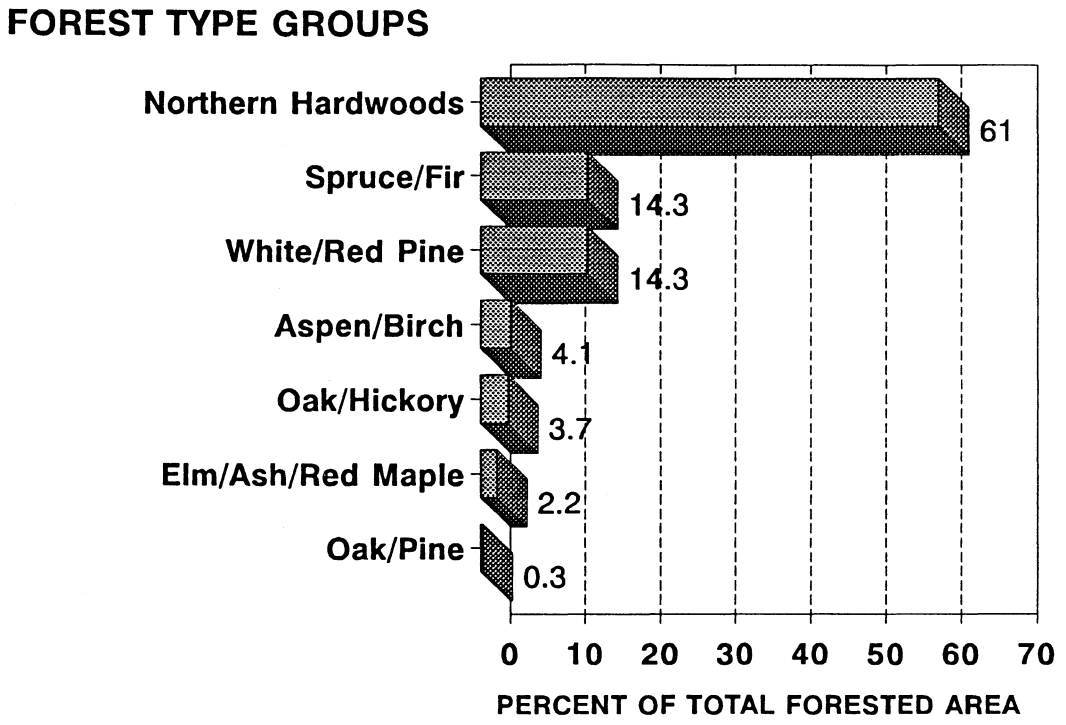
FOREST AND WILDLAND FIRES

Vermont Fire Wardens reported 288 fires that burned a total of 747 acres in 1991. Fires occurred in grassland, brush and woodland. Damage ranged from total plant and tree community loss, to scorched bark on mature trees. In general, fire does not cause serious mortality or tree injury in our forests because they are small in size and intensity.

MAJOR TYPES OF FORESTS IN VERMONT

Vermont's forests consist of a mixture of different species, with poorly defined boundaries between major forest type groups (species commonly growing together). However, there are basically seven forest type groups generally recognized (Figure 6). The majority of our forests are called northern hardwoods, with sugar maple, beech and yellow birch being the major species. The other major forest type groups in Vermont are white/red pine, and spruce/fir forests. Small areas of aspen/birch, oak/hickory, elm/ash/red maple, and oak/pine forest type groups are also found around the state. Each forest type has other species that are commonly found within that grouping (as presented in Frieswyk and Malley, 1985).

For this report we will concentrate discussions on five of the forest type groups, since they include most hardwood and softwood tree species as major components of the group: northern hardwoods, white/red pine, spruce/fir, aspen/birch, and oak/hickory forest type groups.



From: Frieswyk & Malley, 1985

Figure 6. Forest Type Groups in Vermont. The seven major types of forests found in Vermont based on percent of total forest represented by each group.

Northern Hardwood Forest Type Group

Northern hardwood forests are the predominant forest type group in Vermont. Although many tree species can be found growing in this group, six species typify these forests: sugar maple, beech, yellow birch, red maple, pin cherry and black cherry. The other trees commonly growing in northern hardwood forests are white ash, balsam fir, red spruce, paper birch, hemlock, aspen and basswood (Frieswyk and Malley, 1985).

Sixty-one percent of Vermont's growing stock is included in this forest type group (Figure 6). This represents an increase of 1.8% in land area covered by northern hardwood forests from 1973 to 1983 (from: Frieswyk and Malley, 1985).[1]

Fifty percent of these northern hardwood forests contain high stand volumes, with basal areas between 100 and 149 feet per acre. Vermont's forests are aging, as indicated by increasing volumes of sawtimber size trees in the forests. There was an increase of 15.7% in the acres of sawtimber (1,832,300 acres) over the ten year period between 1973 and 1983 (from: Frieswyk and Malley, 1985).

MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH

Sugar Maple

RESOURCE

Sugar maple is the most abundant tree species in Vermont forests (Figures 1 & 2). Twenty-three percent of the growing stock volume and 24% of the sawtimber volume is comprised of sugar maple (from: Frieswyk and Malley, 1985). [3, 4]

The quality of sugar maple logs, a measure of the condition of tree boles, improved between 1973 and 1983 when 11% of the sawtimber log resource was classified as Grade 1 (Figure 7) (from: Frieswyk and Malley, 1985).[1, 5]

Sugar maple trees are harvested for sawlogs, veneer, pulpwood, firewood and whole tree chips (Figure 3 & 4). There was a 6% increase in sawlog and veneer log harvest of sugar maple from 1990 to 1991. A total of 36,827,000 board feet of mature sugar maple was harvested in 1991 (Figure 3).

Of this, 13.8% was exported to other states and countries. Half of the exports went to Canada. [6]

The 1991 sugar maple harvest used for pulp totaled 28,080 cords (Figure 4). The estimated value generated from the 1991 harvest, based on prices for products delivered to the mill or other customers, was $8.22 million (Figure 5) (Dept. of Forests, Parks and Recreation, 1991a). Additional unrecorded quantities of sugar maple were harvested for firewood and whole tree chips.

Another measurable industry utilizing sugar maple is that of maple syrup production, which totaled 440,000 gallons produced in 1991, with a value of $12.54 million (Vt. Dept. of Agriculture, 1991).

Sugar maples are also an important component in producing appealing fall foliage colors. Estimates of the revenues generated by tourism during fall foliage season are $75 million annually.

STRESSES ON SUGAR MAPLES IN 1991

Plentiful moisture during the two previous growing seasons, with warm weather and adequate moisture during leaf expansion, resulted in excellent foliage density this year. However, dry conditions during June and July led to leaf scorch, off-color foliage or leaf drop in mid-summer, especially on trees growing under stressed conditions. Symptoms were particularly severe in northeastern Vermont. Additional symptoms are expected

to show up on generally wet or dry sites over the next couple of years.

Maple leaf cutter damage was recorded on 5,200 acres, mostly in east-central counties (Vt. Dept. of Forests, Parks and Recreation, 1991c). Because maple leaf cutter damage is most intensive late in the growing season, it causes less impact on tree health than other types of defoliating insects. However, this pest may attack trees for several years in a row, reducing tree vigor, with the possibility of tree decline.

Maple trumpet skeletonizer was common this year, with some moderate defoliation detected in Addison and and Windsor Counties.

Other maple pests occurred only at low levels this year. Numbers of pear thrips were low, and rapid budbreak reduced the possibility of damage.

Bruce spanworm moths were seen throughout the state in the fall, suggesting that this insect may cause some damage in the spring of 1992 (Vt. Dept. of Forests, Parks and Recreation, 1991c).

HEALTH

The condition of sugar maples surveyed in 1991 showed that 93.1 to 100% of trees were classified as healthy (Figure 8). This is an improvement over the last few years.

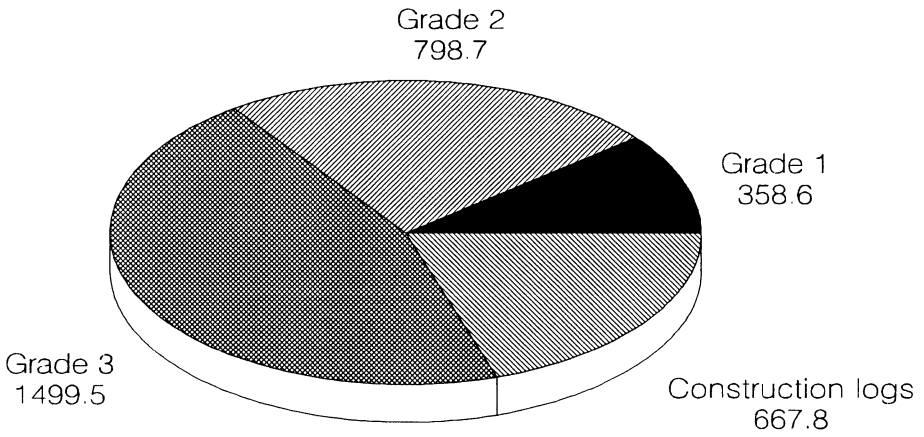
Using the averages of three indicators of forest health, dieback, foliage transparency (the amount of light coming through foliated areas of the crown) and mortality, we can see an overall trend towards improvement in the condition of sugar maples surveyed in the NAMP and NFHM plots (Figure 9 & 10). Mortality levels recorded under the VHTHS were similar to the other surveys in 1991, but this represented an increase from 1986 levels. [7]

The most likely explanations for improvements in sugar maple crown condition since 1988 are: adequate spring precipitation, and a gradual reduction in leaf injury from pear thrips.

Regional results on sugar maple health show similar trends towards improved crown conditions from 1988 to 1991 (see Appendix B)

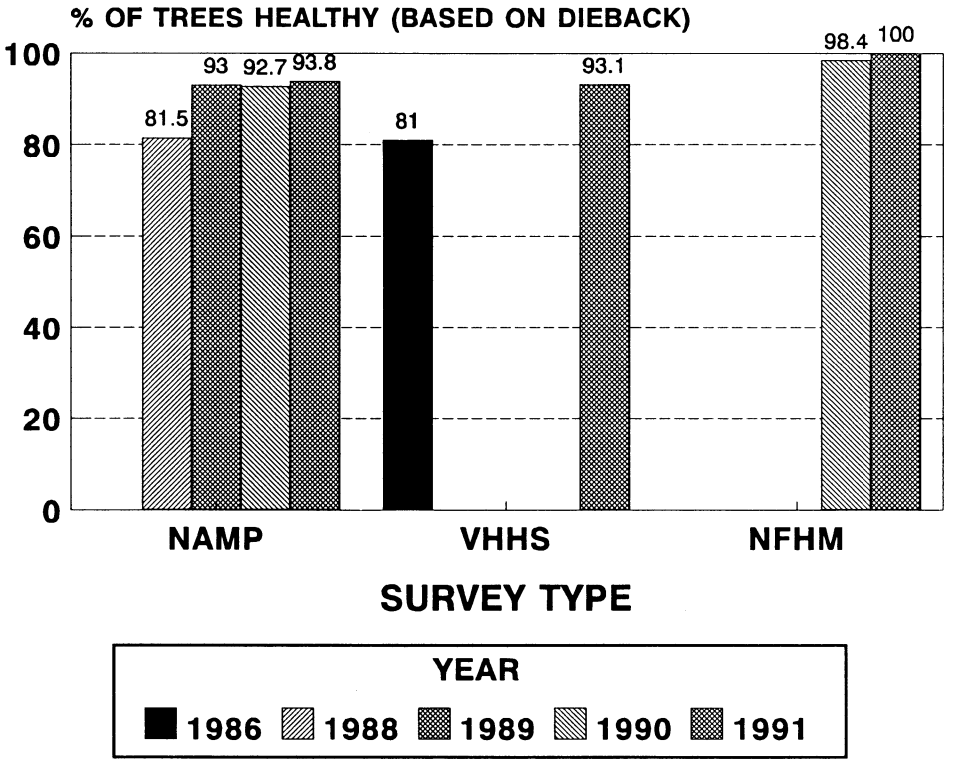
In 1992 we plan to expand the NAMP plot system in Vermont to include areas not represented in our current survey (Appendix A).

Overall, sugar maples had minimal stress with favorable growing conditions in 1991, which resulted in good crown condition. This year sugar maples in Vermont's forests can be considered generally healthy.



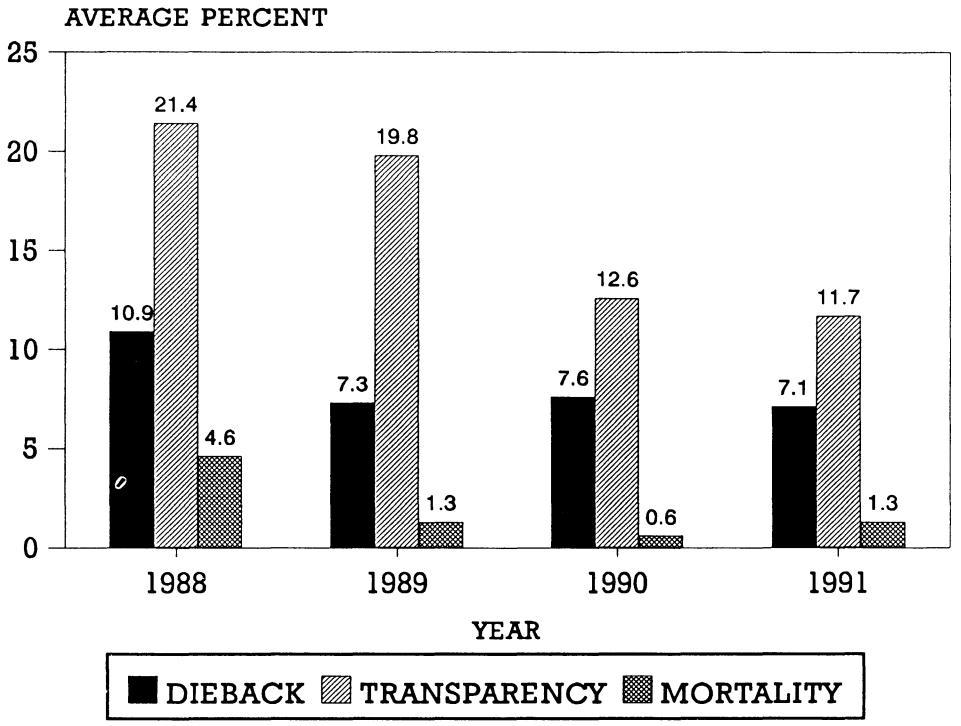
Volumes in millions of board feet
From: Frieswyk & Malley, 1985

Figure 7. Sugar Maple Sawtimber Log Grades, 1983. The quality of potential sugar maple sawtimber logs in Vermont forests as depicted by four log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.



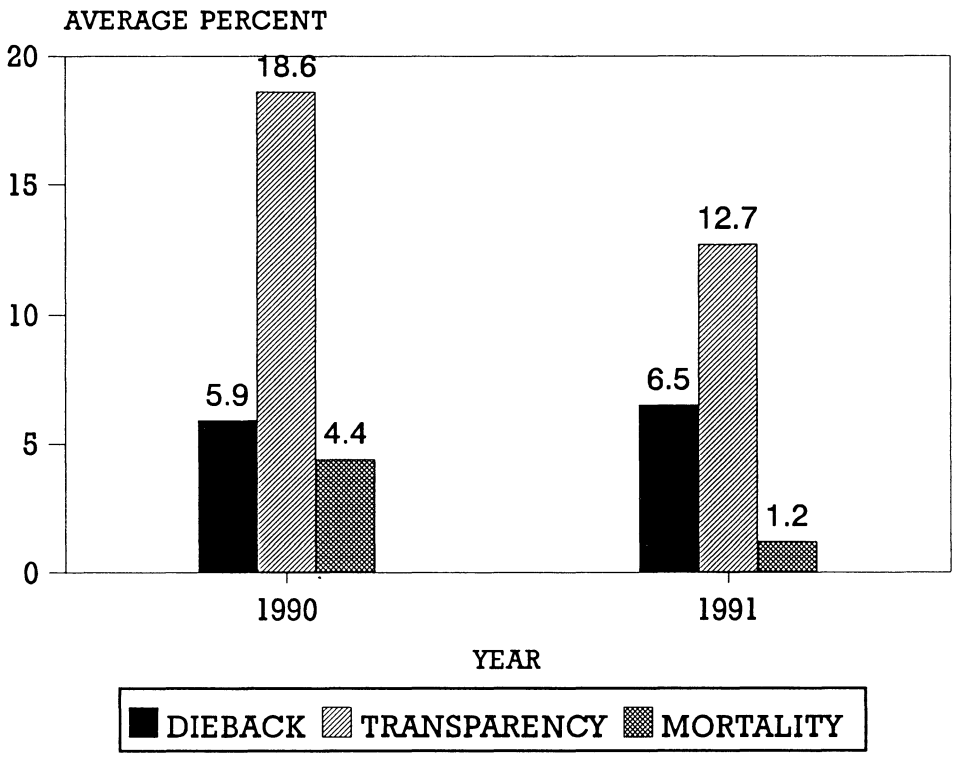
Healthy for each program is: VHTHS-trees with 10% dieback or less; NAMP- trees with 15% dieback or less; and NFHM-trees with 20% dieback or less.

Figure 8. Health of Vermont's Sugar Maples (NAMP, VHTHS, NFHM). Comparisons of sugar maple health results between three types of forest health surveys: NAMP (North American Sugar Maple Project), VHTHS (Vermont Hardwood Tree Health Survey) and NFHM (National Forest Health Monitoring Program), between 1986 and 1991.



Values are the average percent of dieback (recently dead branches), transparency (the amount of light coming through foliage) and mortality.

Figure 9. Trend in the Condition of Vermont's Sugar Maples (NAMP). Comparing trends in three indicators of tree health: dieback, transparency and mortality, from 1988 through 1991 using results from Vermont plots in the North American Maple Project (NAMP). Decreasing values mean that the amount of dieback, transparency and mortality is decreasing, a positive sign of tree health.



Values are the average percent of dieback (recently dead branches), transparency (the amount of light coming through foliage) and mortality.

Figure 10. Trends in Condition of Vermont's Sugar Maples (NFHM). Comparing trends in three indicators of tree health: dieback, transparency and mortality, from 1988 through 1991 using results from Vermont plots in the National Forest Health Monitoring Program (NFHM) from 1990 to 1991. Decreasing values mean that the amount of mortality and transparency is decreasing, positive signs of tree health, while dieback increased.

RESOURCE

Beech is an important species of our northern hardwood forests. In 1983, beech comprised 5.25% of the growing stock and 5.54% of sawtimber in Vermont's forests.[1,8,9] Grade 1 sawtimber logs comprise about 5.4% of mature trees (Figure 11) (from: Frieswyk and Malley, 1985).[10] In addition to importance for timber, beech seeds provide a rich food source to forest wildlife.

Timber harvesting of beech in 1991 totaled 3,900,000 board feet (Figure 3). Of this, 3.7% was exported to other states and countries.[11] An additional 13,447 cords were harvested for pulp (Figure 4), plus unrecorded quantities were used for firewood and whole tree chips harvesting. The 1991 value of the beech harvest, delivered to the mill, was $1.2 million (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON BEECH IN 1991

Beech bark disease continues to cause scattered dieback and chlorosis, although affected acreages observed from the air decreased this year (600 acres of decline and mortality in 1991 versus 1,690 acres in 1990). In ground plots where this disease is monitored, fungal fruiting bodies increased in 1991, despite improvements in crown condition. Favorable growing conditions may account for improved tree condition in spite of an increase in the severity of this disease.

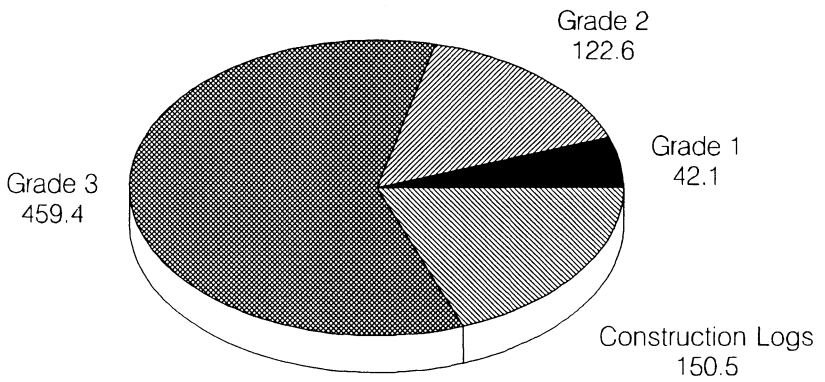
Oystershell scale populations remain low, although dieback associated with recent-past infestations is still noticeable (Vt. Dept. of Forests, Parks and Recreation, 1991c).

HEALTH

In 1991, 81.5% of the beech trees evaluated by the VHTHS were healthy (Figure 12). This is an improvement over previous years. (Vt. Dept. of Forests, Parks and Recreation, 1987). Regional information from the NFHM program reported higher numbers of healthy trees for 1991. However, the definition of healthy under this program includes trees with more dieback than in the VHTHS (see definitions on page 7), which may account for this difference.

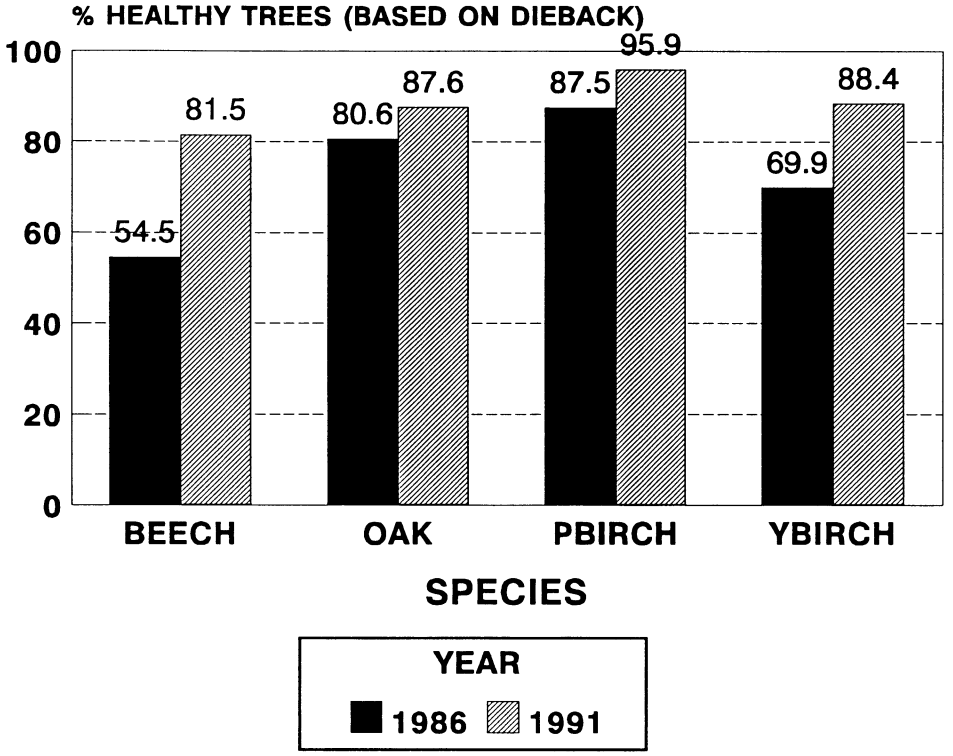
Mortality levels in 1991 for beech surveyed in the VHTHS were 3.5%, an increase from the 1986 level of 1.6% (Figure 13) (Vt. Dept. of Forests, Parks and Recreation, 1993). Regional information from the NFHM program reported that 7.4% of beech trees were dead (see definitions of how mortality is reported under different programs on page 7) (from: Brooks et al, 1991).

Overall, beech condition was fair in 1991, but did improve in comparison to surveys five years ago. However, due to the persistence of beech stress agents, the health of beech will continue to be of concern.



Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 11. Beech Sawtimber Log Grades, 1983. The quality of potential beech sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.



Vt Dept. Forests, Parks & Recr. 1993
The definition of healthy used under VHTHS is trees with 10% dieback or less.

Figure 12. Health of Beech, Oak, Paper Birch (pbirch) and Yellow Birch (ybirch) Trees (VHTHS). Percentage of healthy trees (based on the amount of dieback) between 1986 and 1991, under the VHTHS (Vermont Hardwood Tree Health Survey).

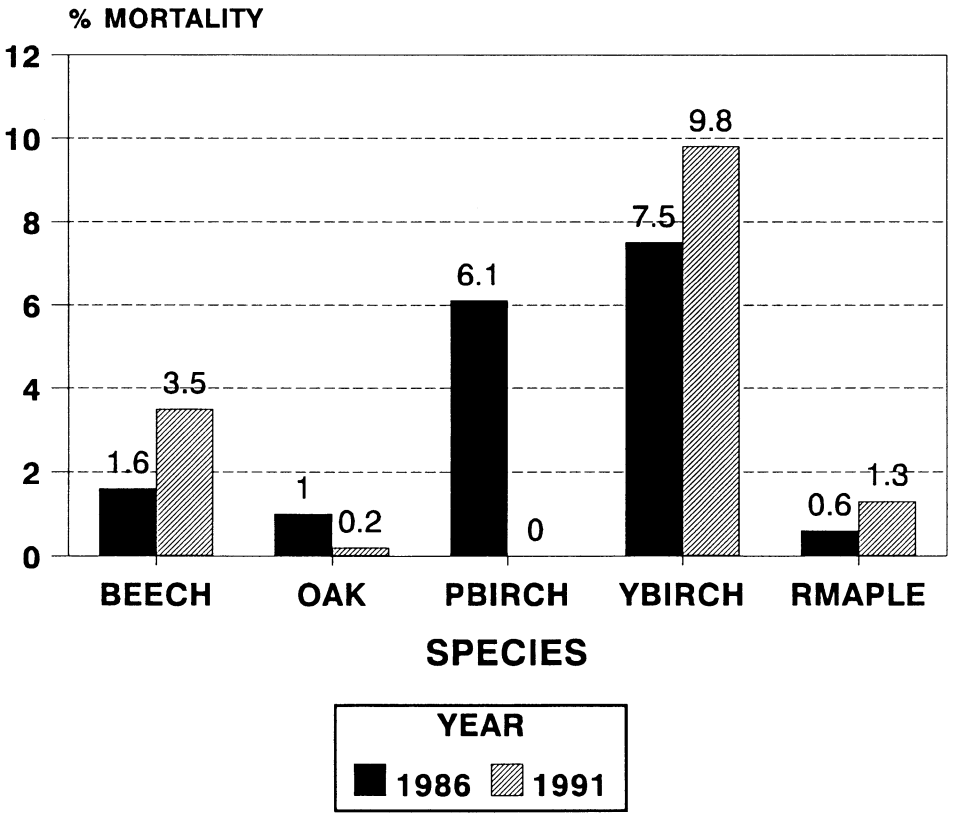


Figure 13. Mortality of Beech, Oak, Paper birch (pbirch), Yellow Birch (ybirch) and Red Maple (rmaple) Trees (VHTHS) from 1986 to 1991.

RESOURCES

Yellow birch totals 7.94% of the growing stock in Vermont forests and 7.78% of the sawtimber trees (Figures 2 & 1).[12] Logs classified as Grade 1 quality totaled 8.8% of sawtimber size trees (Figure 14) (from: Frieswyk and Malley, 1985).[13]

Sawtimber harvesting in 1991 was 10,634,000 board feet, with an additional 26,993 cords harvested for pulpwood (Figure 3 & 4). Exports of sawlogs and veneer to other countries and states was 2,434,000 board feet.

The total estimated value of harvesting was $3.31 million, based on products delivered to mills (Figure 5) (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON YELLOW BIRCH IN 1991

Birch defoliation was widespread late in the season, particularly in northeastern Vermont, and at high elevations in the central Green Mountains (Vt. Dept. of Forests, Parks and Recreation, 1991c). Results from aerial surveys showed that 29,300 acres were affected statewide.

Defoliation may lead to dieback, especially if populations of defoliating insects remain high next year. Previous declines of birch have been linked to climatic factors, such as open winters and dry summers. Because 1991 was a dry summer, some evidence of this may be visible in 1992.

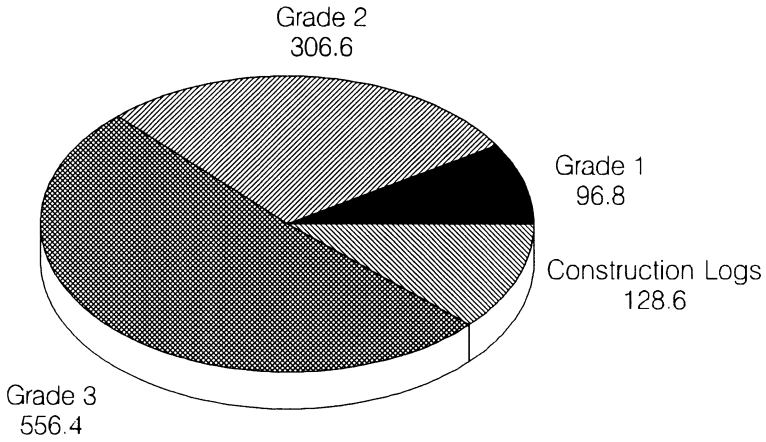
HEALTH

In 1991, 88.4% of yellow birch surveyed were healthy (Figure 12) (Vt. Dept. of Forests, Parks and Recreation, 1993). This is an improvement over conditions recorded in 1986. Higher percentages of trees were considered healthy in the New England survey (see Appendix B) (Eagar et al, 1992).

A localized Essex County survey of yellow birch showed that 84.6% of trees were in the low dieback category (less than 25% dieback), which was similar to values obtained under this survey throughout the last decade (Figure 15) (unpublished data from surveys conducted by Vermont Department of Forests, Parks and Recreation and University of Vermont).

Mortality levels for yellow birch in Vermont were high in 1991 and had increased since 1986 (VHTHS) (Figure 13). Regional mortality levels were also high in 1990 (Brooks et al, 1991).[14] Our Essex County survey showed that mortality levels were low in 1981 but steadily increased to a high of 9.7% in 1991, similar to that of the statewide survey (Figure 15). A cold open winter in 1980-81 may have triggered the decline, with affected trees unable to recover.

Overall, yellow birch in Vermont is in fair condition. Moderately high percentages of crowns are in a healthy condition, but stress from repeated years of defoliation by birch insects poses a threat to future conditions of yellow birch.



Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 14. Yellow Birch Sawtimber Log Grades, 1983. The quality of potential yellow birch sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified into each grade category.

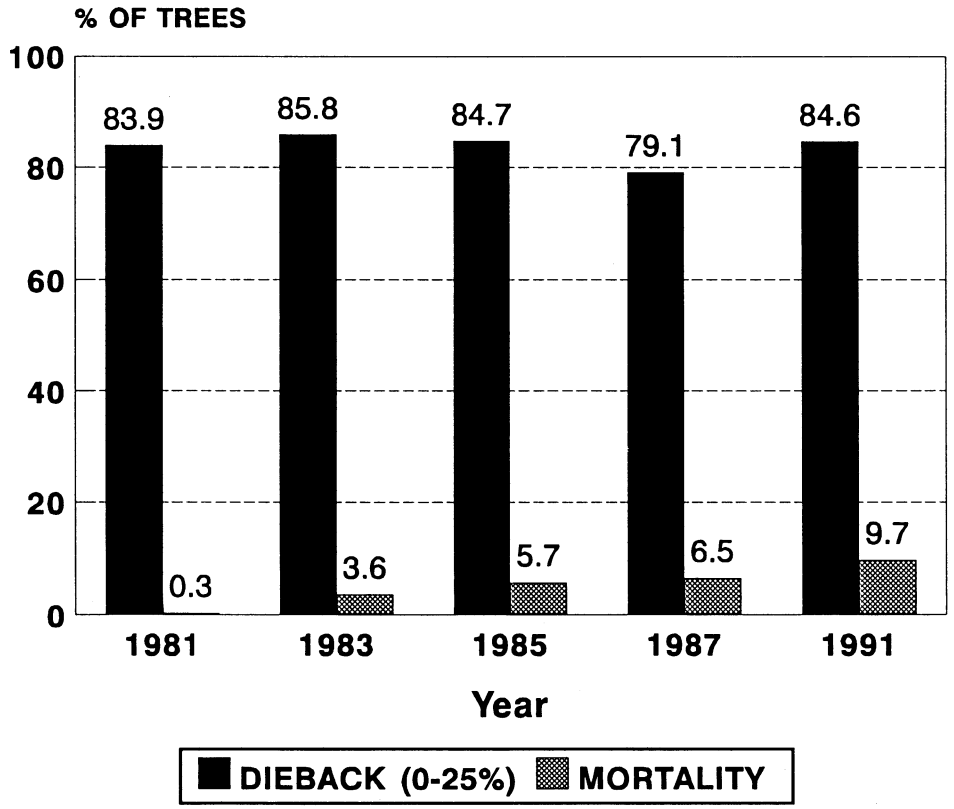


Figure 15. Trend in Condition of Yellow Birch in Essex County. This survey includes plots in only one Vermont county, but does show fairly stable crown conditions (dieback) of live trees over the 10 years between 1981 and 1991, while mortality steadily increases.

Red Maple

RESOURCE

Red maple dramatically increased in abundance from 1966 to 1983. It went from being sixth to second in terms of volume in growing stock. The 1983 inventory found 9.65% of growing stock volume (Figure 2) and 7.81% of sawtimber tree volume (Figure 1) in red maple.[15] Grade 1 quality sawlogs represented 8% of the sawtimber volume (Figure 16) (from: Frieswyk and Malley, 1985).[16]

Harvest of red maple in 1991 totaled 7,745,000 board feet for sawlogs and veneer, and 16,809 cords for pulp (Figure 3 & 4). Red maple sawlogs and veneer exported to other states and countries was 1,155,000 board feet. The total value of revenues from red maple was $1.86 million, based on products delivered to mills (Figure 5) (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON RED MAPLE IN 1991

Red maple often grows on wet sites, where it establishes a shallow root system. When droughts occur, such as this year's dry summer, red maples on wet sites are susceptible to drought injury. It is anticipated that in 1992 red maples will exhibit symptoms from the 1991 dry summer conditions.

HEALTH

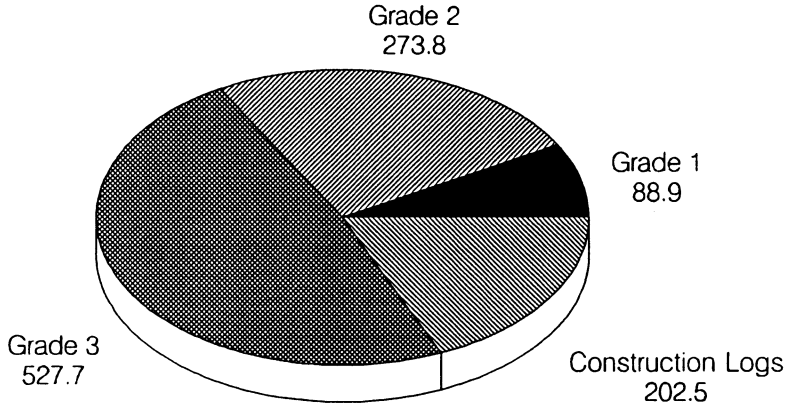
Red maple surveyed in 1991 showed that 90.8 to 97.4% of trees were healthy (Figure 17). The health of red maples improved greatly since the 1986 VHTHS survey, whereas a small decrease in the health of Vermont trees was observed from 1990 to 1991 under the NFHM program.

Regionally, a high percentage of red maples were reported to be in a healthy condition in 1991 (Appendix B) (Eagar et al, 1992).

An index of the two main indicators of forest health, average percent of dieback and transparency shows a trend towards improved crown conditions from 1990 to 1991, while a third indicator, mortality, increased over the two years (NFHM) (Figure 18). This may reflect past stresses that have resulted in tree mortality, while remaining trees are improving their health.

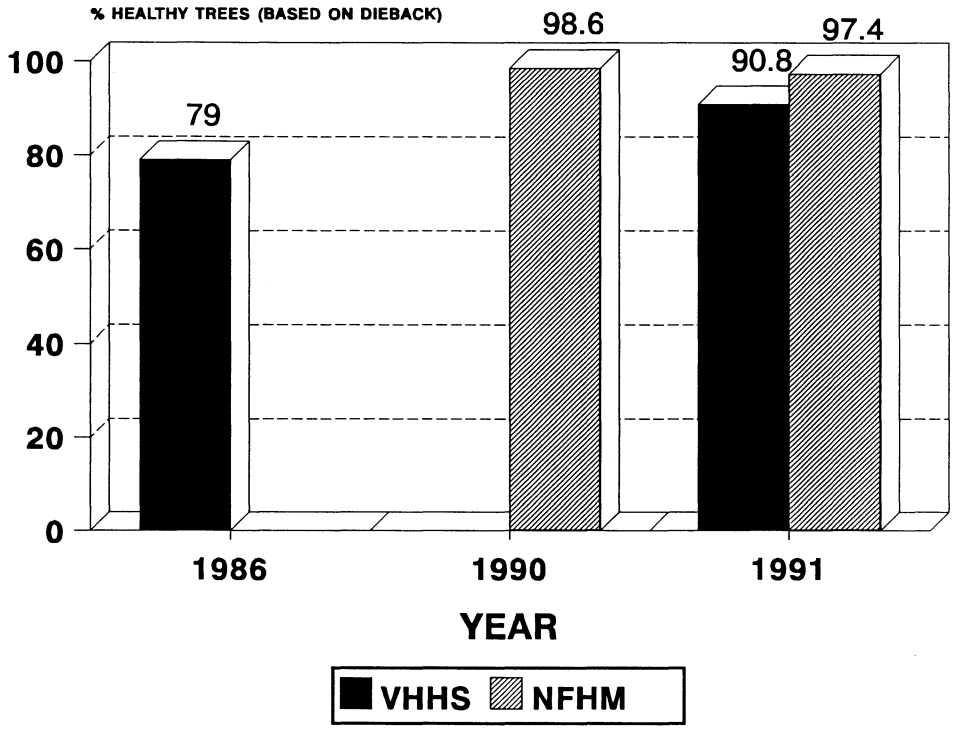
The VHTHS also shows an increase in mortality from 1986 to 1991 (Figure 13) (Vt. Dept. of Forests, Parks and Recreation, 1993). Mortality of red maple across New England was found to be slightly lower than that of Vermont trees (Brooks et al, 1991).[17]

Overall, the health of red maple in 1991 was good. Dry summer conditions may have posed some stress to trees with shallow root systems, but otherwise, few stressors affected red maple in 1991.



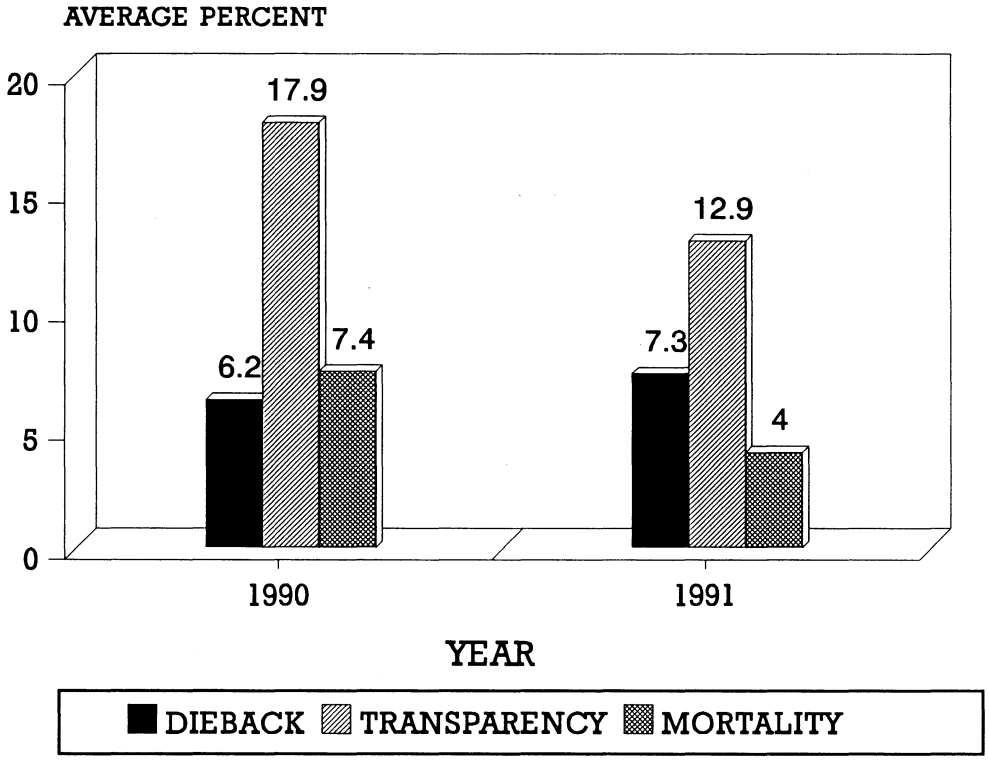
Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 16. Red Maple Sawtimber Log Grades, 1983. The quality of potential red maple sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.



Vt Dept. Forests, Parks & Recr. 1993
The definition of healthy used under VHTHS is trees with 10% dieback or less, whereas healthy as defined by the NFHM is trees with 20% dieback or less.

Figure 17. Health of Vermont's Red Maples (VHTHS, NFHM). Comparisons of red maple health results (based on dieback) between two types of forest health surveys: VHTHS (Vermont Hardwood Tree Health Survey) and NFHM (National Forest Health Monitoring Program), between 1986 and 1991.



Values are the average percent of dieback (recently dead branches), transparency (the amount of light coming through foliage) and mortality

Figure 18. Trends in Condition of Vermont's Red Maples (NFHM). Comparing trends in three indicators of tree health: dieback, transparency and mortality, from 1990 through 1991 using results from Vermont plots in the National Forest Health Monitoring Program (NFHM). Decreasing values mean that the amount of transparency is decreasing, a positive sign of tree health. Dieback increased slightly, a possible indication of past stress.

White Ash

RESOURCE

White ash makes up 4.36% of the growing stock volume (Figure 2) and 4.17% of the sawtimber tree volume (Figure 1) in Vermont forests.[18, 19] White ash sawlog quality is high. Grade 1 sawlogs comprised 24% of sawtimber volume (Figure 19) (from: Frieswyk and Malley, 1985).[20]

The value of white ash harvested in 1991 totaled $1.97 million (Figure 5). This was in the form of sawlogs, 10,098,000 board feet, and pulpwood, 3,362 cords (Figure 3 & 4). Exported ash sawlogs and veneer logs totaled 1,041,000 board feet in 1991 (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON WHITE ASH IN 1991

Ash yellows, a disease caused by a mycoplasma-like organism, continues to cause some dieback and mortality on ash, especially in the Champlain Valley and in southern Vermont. Some localized defoliation of roadside white ash occurred in southern Vermont (Readsboro) caused by the blackheaded ash sawfly (Vt. Dept. of Forests, Parks and Recreation, 1991c).

HEALTH

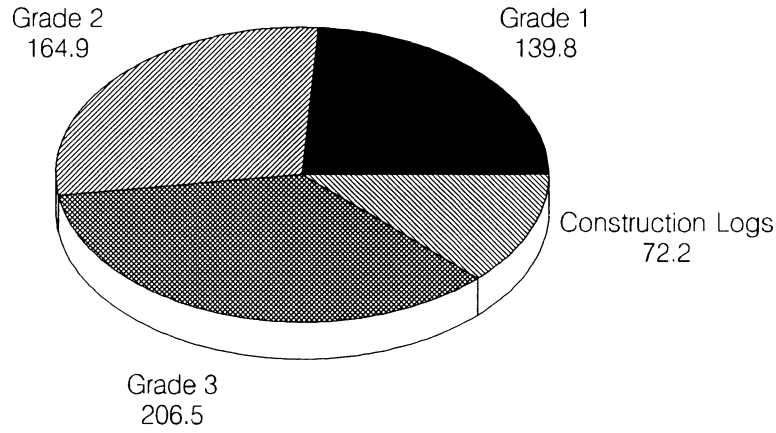
In 1991, 90.7 to 98.5% of Vermont's white ash trees were healthy (VHTHS and NAMP VT data) (Figure 20). This was an improvement from previous years.

White ash dieback on trees in Vermont NAMP plots has remained constant since 1989. Foliage transparency has fluctuated each year, with an improved or lowered foliage transparency in 1990 and a greater foliage transparency in 1991. Mortality in these plots has decreased since 1988, such that the 1990 and 1991 surveys found no new mortality (Figure 21). The VHTHS differed from this trend, reporting that ash mortality increased from 1.8% in 1986 to 9.5% in 1991 (Vt. Dept. of Forests, Parks and Recreation, 1993).

Regional information on white ash from the 1991 NFHM survey showed crown condition results similar to Vermont data (see Appendix B) (Eagar et al, 1992), with 4.4% of trees dead in the 1990 survey (Brooks et al, 1991).

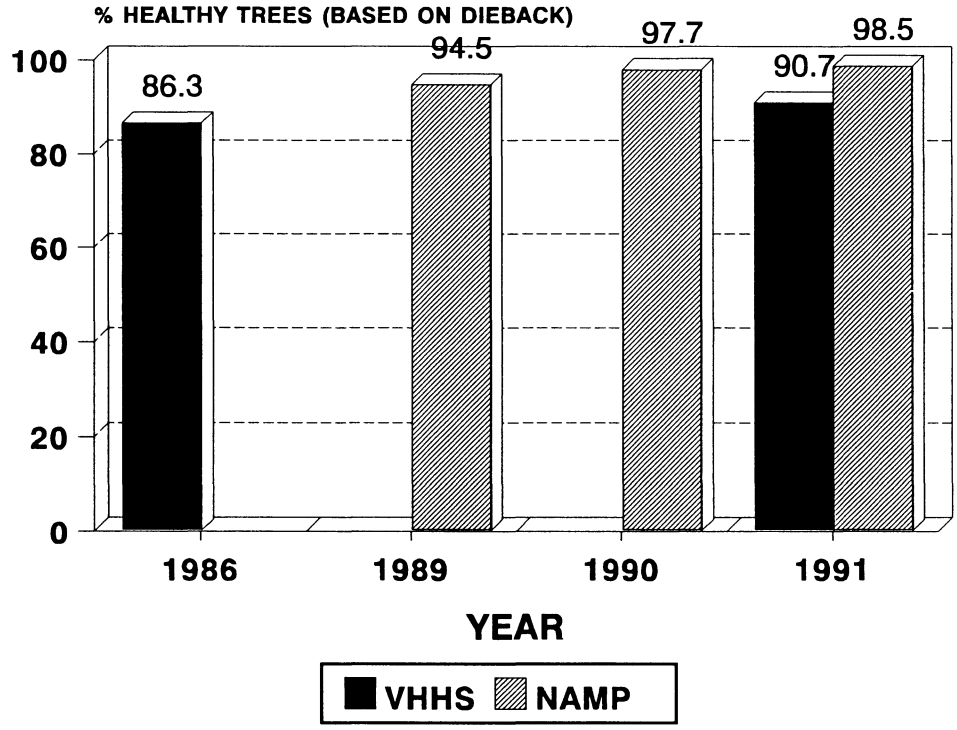
Pockets of ash decline exist in Vermont. NAMP plots are not intended to survey representative ash stands, so results from this survey indicate a healthier ash population than does the VHTHS. Yet the white ash represented in the VHTHS may exaggerate ash decline, since these trees come from areas in the Champlain Valley where ash yellows is prominent. Plans are being made to establish plots to examine the effects of ash yellows on our white ash resource.

Overall, our survey results found white ash to be in a generally healthy condition in 1991. Some stress from ash yellows disease was evident in certain locations, but otherwise, 1991 had few stressors and favorable growing conditions for ash.



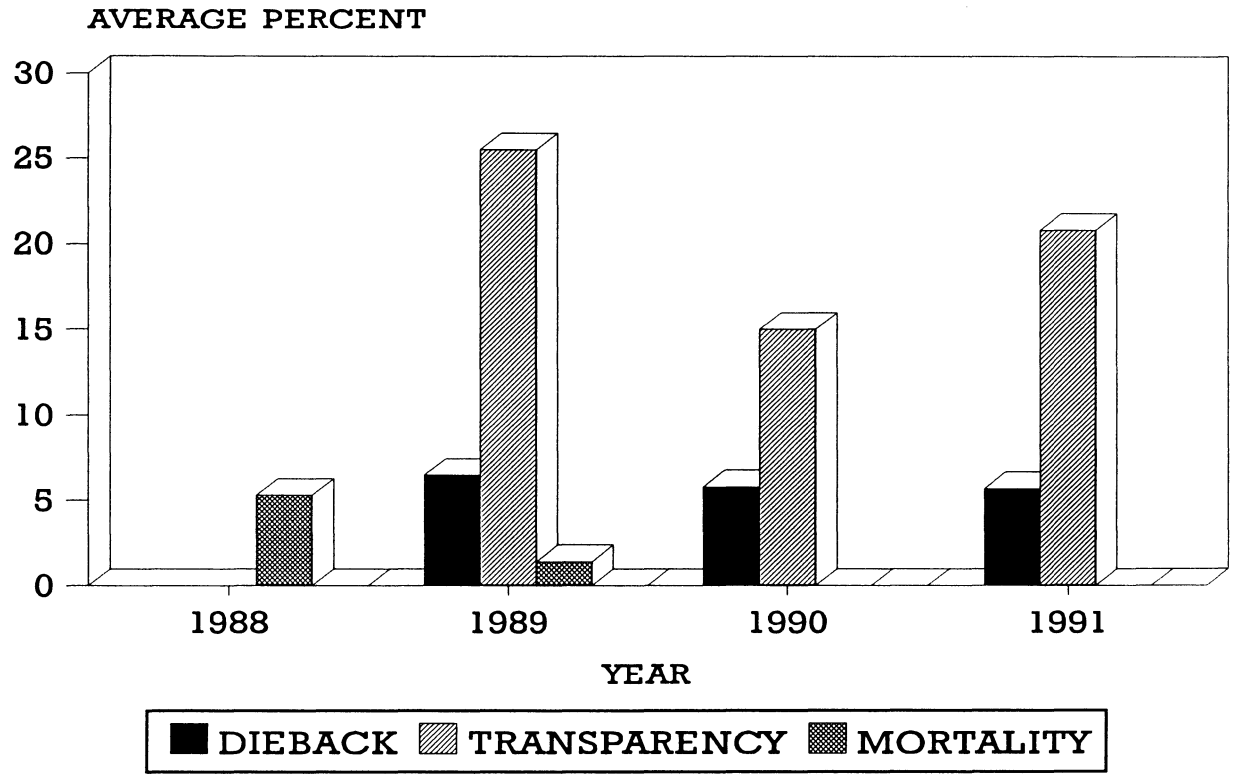
Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 19. White Ash Sawtimber Log Grades, 1983. The quality of potential white ash sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.



Vt Dept. Forests, Parks & Recr. 1993
The definittion of healthy used under VHTHS is trees with 10% dieback or less, whereas healthy as defined by the NAMP is trees with 15% dieback or less.

Figure 20. Health of Vermont's White Ash (VHTHS, NFHM). Comparisons of white ash health results (based on dieback) between two types of forest health surveys: VHTHS (Vermont Hardwood Tree Health Survey) and NAMP (North American Maple Project), between 1986 and 1991.



Values are the average percent of dieback (recently dead branches), transparency (the amount of light coming through foliage) and mortality.

Figure 21. Trends in Condition of Vermont's White Ash (NAMP). Comparing trends in three indicators of tree health: dieback, transparency and mortality, from 1988 through 1991 using results from Vermont plots in the North American Maple Project (NAMP). Decreasing values for dieback, transparency and mortality are a positive sign of past and current year tree health.

Spruce/Fir Forest Type Group

Spruce/fir forests typically contain red spruce, northern white-cedar, balsam fir, white spruce, black spruce, and tamarack. Other species found growing in these forests include paper birch, red maple, aspen, white pine, hemlock and sugar maple. This forest type group comprises 14% of Vermont's forests, with a higher concentration of spruce/fir in the northeastern portion of the state (Frieswyk and Malley, 1985) (Figure 6).

These forests are important as overwintering grounds for deer and other wildlife, as they provide a shelter from winter weather. In addition, they accounted for nearly one-quarter of the revenues generated from the 1991 harvest based on values delivered to mills (Vt. Dept. of Forests, Parks and Recreation, 1991a) (Figure 5).

MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH

Balsam Fir

RESOURCE

Balsam fir is one of the top 10 species in terms of abundance in Vermont's forests (Fig. 1&2). It comprises 5.64% of the growing stock and 4.76% of the sawtimber tree volume (from: Frieswyk and Malley, 1985).[21, 22] Log grades are not used for most softwood species, including balsam fir.

Harvest figures recorded for this species are combined with those of spruce. The total harvest for spruce/fir sawtimber in 1991 was 82,565,000 board feet (Figure 3), and 130,545 cords of pulpwood (Figure 4). Sixty-four percent of the sawlogs harvested were exported to other states and countries, with 75% of exports going to Canada. The total revenue generated was $20.41 million, based on products delivered to mills or other customers (Figure 5) (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON BALSAM FIR IN 1991

Adult moth populations of spruce budworm, an insect defoliator of both balsam fir and spruce trees, were higher this year than in the recent past. Although no defoliation was visible this year, this sudden population increase could signal the beginning of another outbreak by this serious pest.

Hemlock looper moths were commonly seen in the fall throughout the state. This insect has caused widespread balsam fir defoliation in Maine and eastern Canada over the last ten years.

Balsam twig aphid populations increased in southern Vermont, with damage occurring throughout the region.

Balsam gall midge caused serious damage to balsam fir Christmas trees, especially in northern Vermont plantations, although the extent and severity of damage dropped from 1990 levels.
Late-spring frost damaged new growth on Christmas trees throughout much of northern Vermont.

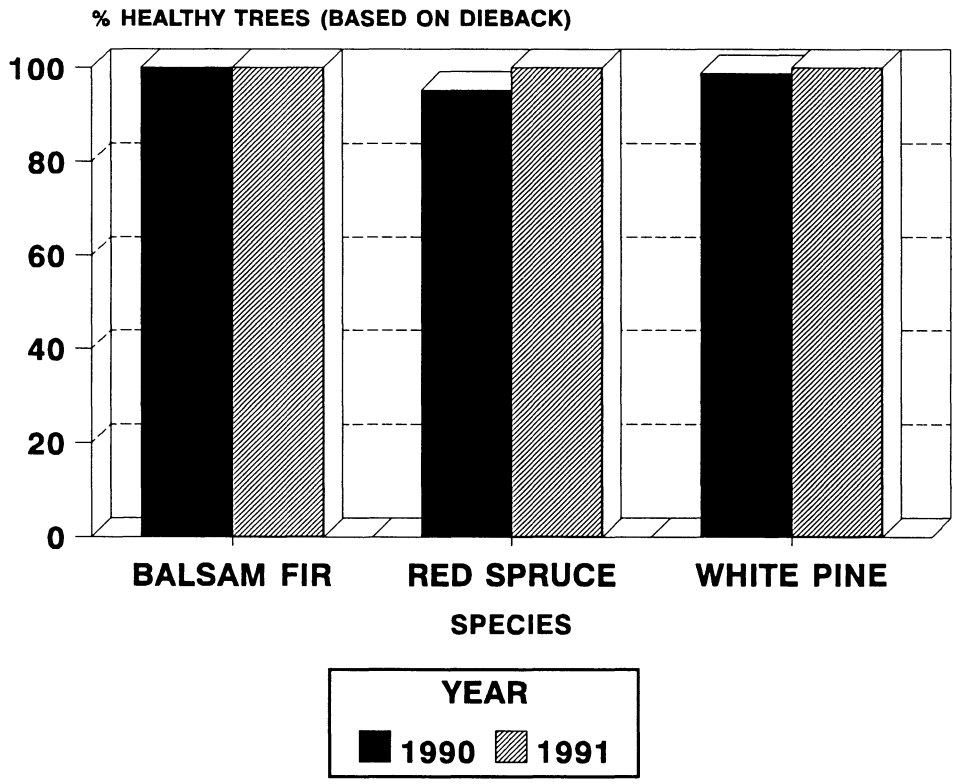
HEALTH

In 1991, all balsam fir surveyed in Vermont under the NFHM program were considered healthy (Figure 22). This was also the case in 1990. New England data showed similar high percentages of healthy trees (see Appendix B) (Eagar et al, 1992).

The trend in condition for balsam fir indicates that both dieback and foliage transparency have remained the same for the past two years, while mortality has decreased from 5 to 0% levels, from 1990 to 1991 (Figure 23).

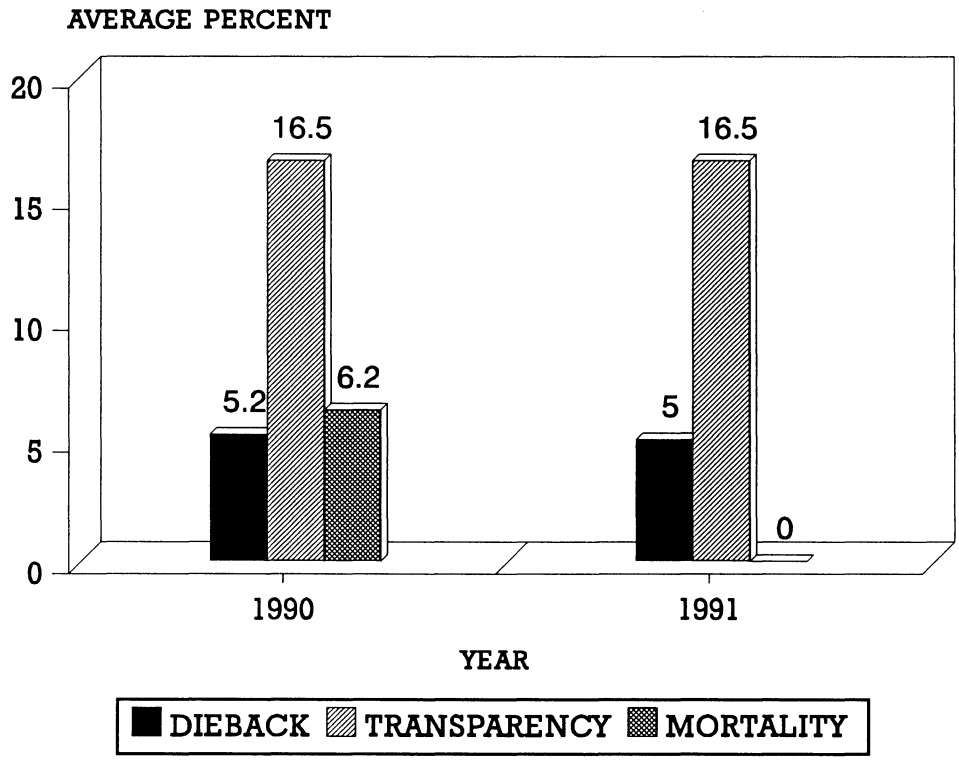
Mortality levels are much lower on Vermont plots than elsewhere in the region. Mortality of balsam fir in 1990 in New England plots was 26.1% (Brooks et al, 1991). This reflects both past (standing dead) and recent mortality, so is expected to be higher than annual mortality levels.

Overall, our surveys showed that balsam fir was in a healthy condition in 1991. There are small geographical areas where high elevation weather extremes are stressing trees, but the majority of the balsam fir resource showed little sign of stress this year.



The definition of healthy used under NFHM is trees with 15% dieback or less.

Figure 22. Health of Vermont's Balsam Fir, Red Spruce and White Pine (NFHM). Percentage of healthy (based on dieback) balsam fir, red spruce and white pine trees rated as healthy between 1990 and 1991, under the NFHM (National Forest Health Monitoring Program).



Values are the average percent (recently dead branches), transparency (the amount of light coming through foliage) and mortality.

Figure 23. Trend in Condition of Vermont's Balsam Fir (NFHM). Comparison of trends in three indicators of tree health: dieback, transparency and mortality, from 1990 through 1991 using results from Vermont plots in the National Forest Health Monitoring Program (NFHM). Decreasing values for dieback, and mortality are a positive sign of past and current year tree health.

Red Spruce

RESOURCE

Red spruce is one of the 10 most abundant species in Vermont's forests (Figure 6). It comprises 7.69% of the growing stock, and 8.42% of the sawtimber tree volume (from: Frieswyk and Malley, 1985).[23] Log grades are not used for most softwood species, including spruce.

Harvesting figures for red spruce are combined with balsam fir (see balsam fir for values).

STRESSES TO RED SPRUCE IN 1991
[see spruce budworm information under balsam fir]

Winter injury of high elevation red spruce has caused growth reduction and mortality of these trees (Eagar and Adams, 1992). Red spruce is not as tolerant of winter weather as other conifer species, especially rapid fluctuations in winter temperatures. In addition, studies have demonstrated that red spruce trees growing at high elevations are exposed to high levels of acid deposition (acid rain), and there is evidence that this acidic deposition may enhance the injury already existing from winter weather.

Although we are not currently recording annual changes in Vermont's high elevation red spruce trees, we can assume that this stress combination is continuing to affect these trees.

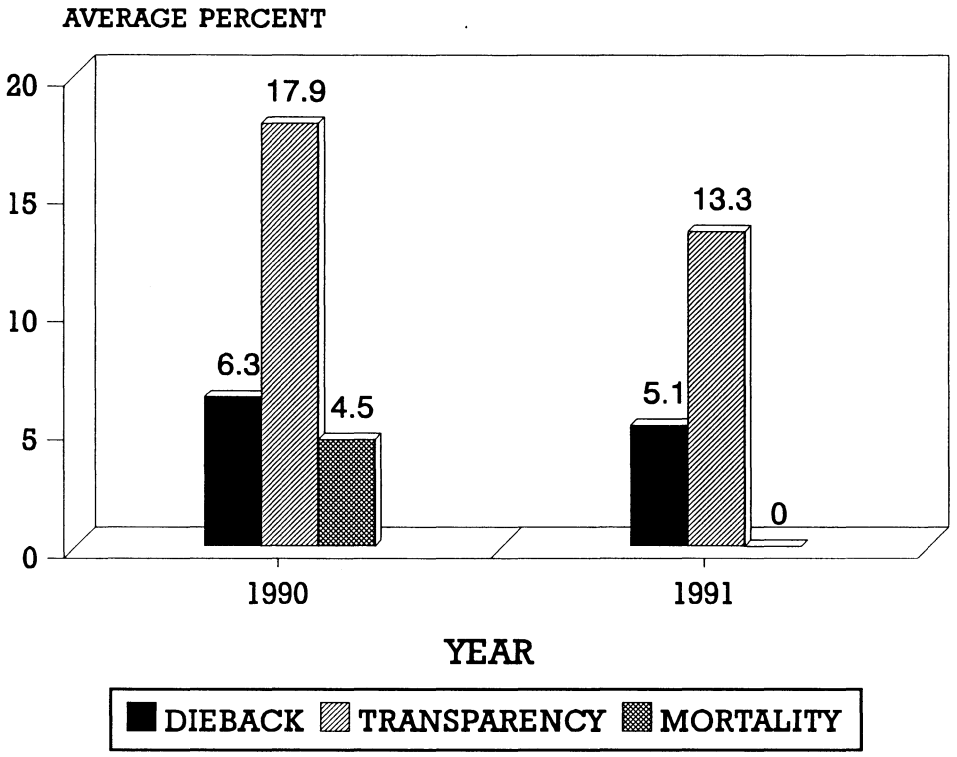
HEALTH

In 1991, all red spruce surveyed on Vermont NFHM plots were considered healthy (Figure 22). This is an improvement from 1990 when 95.2% were healthy. New England data for 1991 showed similar high percentages of healthy trees (see Appendix B) (Eagar et al, 1992).

Trends in condition from 1990 to 1991 show an improvement in the amount of foliage transparency, dieback and mortality (Figure 24). Mortality levels in Vermont were somewhat lower than those measured in New England, with levels in 1990 under the NFHM program at 8.1% (Brooks et al, 1991).

In an attempt to better monitor the health of high elevation red spruce, plans are underway to establish plots at elevations of 3000 feet and above. This will provide long-term information on the trends in health of high elevation tree species as it relates to weather, air quality problems and other forest stresses.

Overall, the condition of red spruce in Vermont was good in 1991. Environmental stress on red spruce at high elevations continues to be of concern, but otherwise, little stress on this species was detected this year.



Values are the average percent of dieback (recently dead branches), transparency (the amount of light coming through foliage) and mortality.

Figure 24. Trend in Condition of Vermont's Red Spruce (NFHM). Comparing trends in three indicators of tree health: dieback, transparency and mortality, from 1990 through 1991 using results from Vermont plots in the National Forest Health Monitoring Program (NFHM). Decreasing values for dieback, transparency and mortality are a positive sign of past and current year tree health.

White/Red Pine Forest Type Group

White/red pine forests have white pine, hemlock or red pine composing the majority of tree species. Other species growing in these forests are sugar maple, red maple, red spruce, balsam fir and paper birch. Pine forests account for 14% of Vermont's forested area or 631,300 acres (Figure 6) (from: Frieswyk and Malley, 1985).

MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH

White Pine

RESOURCE

White pine comprised 7.15% of Vermont's growing stock volume and 10.16% of the sawtimber tree volume (Figure 2 & 1). [24] In terms of sawtimber trees, it is the third most abundant species (from: Frieswyk & Malley, 1985). White pine sawtimber quality is hindered by bole defects caused by the white pine weevil.

The white pine volume harvested for sawlogs exceeded any other species this year, 55,187,000 board feet (Figure 3). Twenty-nine percent of sawlogs were exported to other states and countries. An additional 32,548 cords were harvested for pulp (Figure 4). The revenue generated from this species exceeded any other single species, and was $10.96 million for this year, based on products delivered to mills or other customers (Figure 5) (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON WHITE PINE IN 1991

Although no widespread problems occurred on white pine, a number of stress symptoms were observed. A needlecast disease and needle browning were present in scattered southern Vermont locations. No major health impact is expected from either of these problems.

Mortality continues to occur on some marginally wet sites, brought on by high water levels in the wet growing seasons of 1989 and 1990 (Vt. Dept. of Forests, Parks and Recreation, 1991c).

White pine is a species known to be sensitive to high ozone levels. It is used as a biomonitor, a plant species that reliably exhibits symptoms of ozone injury when high levels are present.

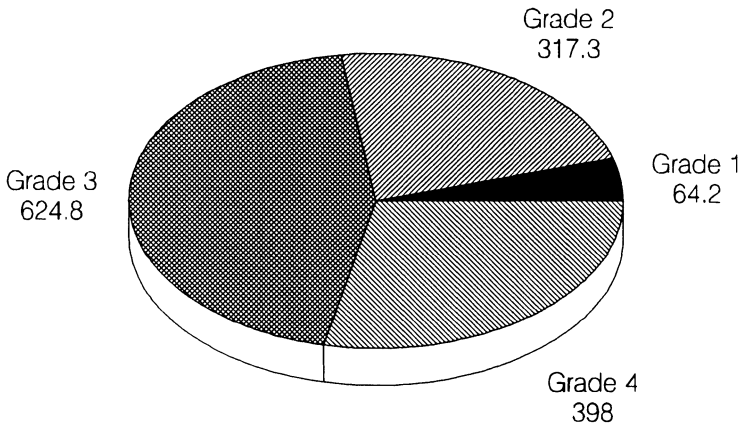
In 1991, symptoms of ozone damage were recorded from other sensitive plant species, and it can be assumed that some white pine in the state were also affected, but to what degree is not known. No damage was detected on ground plots nor from aerial surveys.

HEALTH

All white pines surveyed in Vermont were found to be healthy in 1991 from NFHM Vermont data (Figure 21). This was an improvement from 1990. In 1991, similar high percentages of healthy white pines were recorded in New England (see Appendix B) (Eagar et al, 1992).

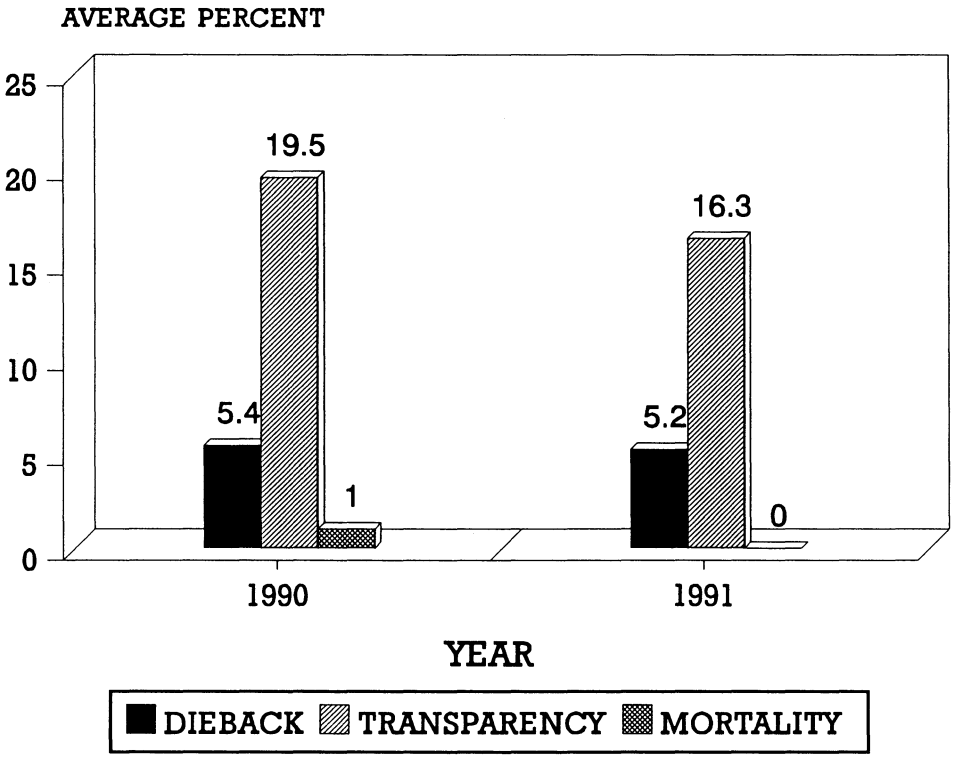
White pine condition improved slightly based on the amount of foliage transparency, dieback and mortality, with no new mortality present in 1991 (Figure 26). New England data shows 9.1% mortality for 1990 (Brooks et al, 1991), as compared to 1.0% in Vermont.

Overall, Vermont white pine was in very good health in 1991. No major stress agents were detected this year, but white pine weevils continue to adversely affect the quality of our white pine timber resource.



Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 25. White Pine Sawtimber Log Grades, 1983. The quality of potential white pine sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.



Values are the average percent of dieback (recently dead branches), transparency (the amount of light coming through foliage) and mortality.

Figure 26. Trend in Condition of Vermont's White Pine (NFHM). Comparing trends in three indicators of tree health: dieback, transparency and mortality, from 1990 through 1991 using results from Vermont plots in the National Forest Health Monitoring Program (NFHM). Decreasing values for dieback, transparency and mortality are a positive sign of past and current year tree health.

Hemlock

RESOURCE

Hemlock is an important component of Vermont's forests. It ranks third in growing stock volume, 8.29% and second in sawtimber tree volume, 10.16% (Figure 2 & 1) (from: Frieswyk and Malley, 1985).[25] Log grades are not used for most softwood species, including hemlock.

Timber harvesting of hemlock in 1991 totaled 12,556,000 board feet of sawlogs and veneer logs, and an additional 53,875 cords of pulp. A small portion of sawlogs, 16%, were exported to other states and countries. The value of revenues from the 1991 harvest were $4.27 million, based on products delivered to mills (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON HEMLOCK

The spring hemlock looper caused defoliation on 1,600 acres in Windham County in 1991. Some mortality is expected as a result. Both the spring and fall hemlock looper populations increased this year, with fall hemlock looper moths detected throughout the state. Until 1990, when 10 acres of defoliation were detected, neither of these insects had been a recent pest in Vermont.

Southern New England states have reported damage from the hemlock wooly adelgid. This insect is new to the area and is threatening tree health in infested areas. Vermont does not yet have an established population of this insect, and plans are underway to conduct extensive surveys for this pest to aid in combating any potential damage to our hemlock resource.

HEALTH

Hemlock distribution in Vermont is widespread, but there are too few hemlock trees in our forest health plot system, making it difficult to determine the status and trends in the condition of this species throughout the state. Plans are underway to improve this. Plots will be established to closely monitor hemlock looper populations, resulting damage to trees and overall hemlock condition statewide.

Regional data results indicate that hemlock in New England is in a generally healthy condition (see Appendix B) (Eagar et al, 1992).

Aspen/Birch Forest Type Group

Aspen/birch forests have aspen, paper birch and gray birch comprising the majority of tree species. Other species growing in these forests are balsam fir, red maple, red spruce, white ash and white pine. Aspen/birch forests account for 4.1% of Vermont's forested area or 182,800 acres (Figure 6) (from: Frieswyk and Malley, 1985).

MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH

Paper Birch

RESOURCE

The growing stock of paper birch in Vermont forests comprises 6.55% of the total stock (Figure 2).[1] Sawtimber in paper birch is 3.41% of the total (Figure 1).[26] Logs classified as Grade 1 quality totaled 6% of the sawtimber resource (Figure 27) (Frieswyk and Malley, 1985).[27]

Paper birch logs are harvested for sawtimber, boltwood and pulpwood. Trees harvested in 1991 produced 7,745,000 board feet of sawtimber (Figure 3), 1,502 cords of boltwood and 6,723 cords of pulpwood (Figure 4). The total estimated value delivered to the mills was $1.47 million (Figure 5). Sawlog and veneer exports of paper birch in 1991 were 2,930,000 board feet (Vt. Dept. of Forests, Parks and Recreation, 1991a).

STRESSES ON PAPER BIRCH IN 1991

(see STRESSES ON YELLOW BIRCH IN 1991, page 20)

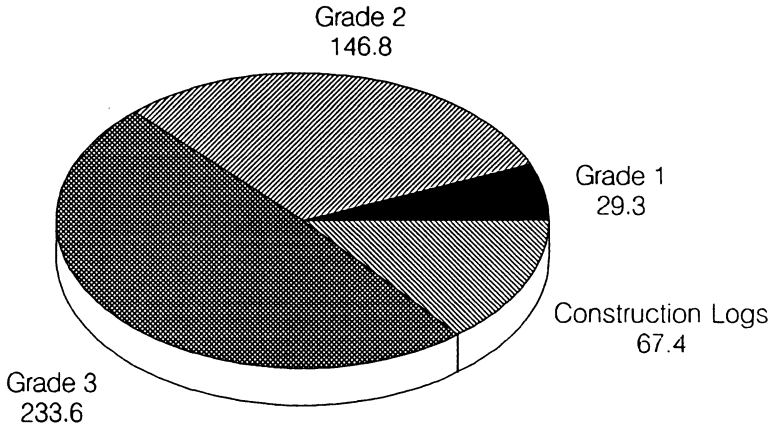
HEALTH

In 1991, 95.9% of paper birch trees surveyed were healthy (Figure 12). This is an improvement from the 1986 VHTHS levels. Regional data shows similar results for 1991 (see Appendix B) (Eagar et al, 1992).

No new trees died from 1986 to 1991 on VHTHS plots (Figure 13) (Vt. Dept. of Forests, Parks and Recreation, 1993). Regional information showed high levels of paper birch mortality in 1990 (Brooks et al, 1991),[28] some of this may reflect past mortality with trees standing dead for numerous years.

Repeated years of birch defoliation in certain areas of Vermont may be affecting the productivity and vigor of these birch trees. Plans are being made to establish plots where we can monitor the health of trees undergoing numerous years of defoliation.

Overall, our survey results indicate that paper birch was in a generally healthy condition in 1991, although repeated years of defoliation by birch insect pests does pose a potential threat to the future health of this species.



Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 27. Paper Birch Sawtimber Log Grades, 1983. The quality of potential paper birch sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified into each grade category

Oak/Hickory Forest Type Group

Oak/hickory forests have oaks, red maple and hawthorn comprising the majority of tree species. Other species growing in these forests are white pine, paper birch, red spruce, beech, hemlock and sugar maple. Oak/hickory forests account for 3.7% of Vermont's forested area or 164,400 acres (Figure 6)(from: Frieswyk and Malley, 1985).

MAJOR SPECIES: RESOURCE, STRESSES AND HEALTH

Oak

RESOURCE

The predominant oak species in Vermont are red and white oak, with red oak being the more abundant species of the two. Red oak comprises only 3.17% of growing stock in Vermont, and 3.95% of the sawtimber trees.[29] A relatively large percentage of red oak sawtimber are in high quality logs. Twenty-six percent of logs were Grade 1 quality (Figure 28) (from: Frieswyk and Malley, 1985).[30]

White oak distribution and abundance is much more limited, with only 0.4% of growing stock volume and 0.4% of sawtimber represented by this species.[31] Logs of Grade 1 quality represent 10% of white oak sawtimber trees (Figure 29) (from: Frieswyk and Malley, 1985).[32]

In 1991, harvesting of oak for sawlog and veneer totaled 10,314,000, board feet with an additional 494 cords harvested for pulp (Figure 3 & 4). Export of oak sawlogs and veneer logs to other states and countries totaled 3,028,000 board feet with 90.5% of exports going to foreign buyers.

The estimated value of the 1991 harvest of oak is $3.12 million (Vt. Dept. of Forests, Parks and Recreation, 1991a). Unrecorded volumes of oak were harvested for firewood and whole tree chips.

STRESSES ON OAK IN 1991

Gypsy moth populations have generally collapsed, although concentrations of egg masses can still be found in a few locations in Bennington County. Most of the 8,000 acres of defoliation recorded in 1991 were in southwestern Vermont (Vt. Dept. of Forests, Parks and Recreation, 1991c). Where defoliation occurred on droughty sites, tree stress may be great due to the added impacts from dry summer weather in 1991.

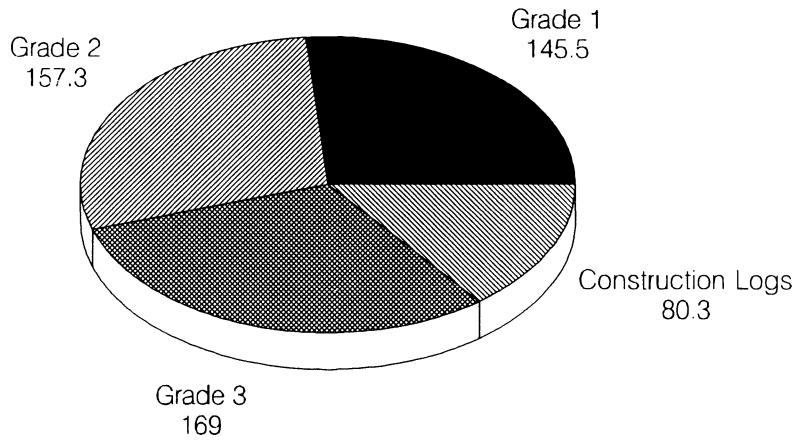
HEALTH

Vermont oak surveyed in the VHTHS showed 87.6% of trees healthy in 1991 (Figure 12) (Vt. Dept. of Forests, Parks and Recreation, 1993). This is an improvement from 1986.

Regional data from the NFHM program in 1991 showed much higher numbers of healthy red oak trees (Appendix B) (Eagar et al, 1992). This may be due to differences between the two programs in their definition of healthy (see page 7) or may reflect differences in crown condition between Vermont and other New England states, possibly due to differences in gypsy moth defoliation cycles around the region.

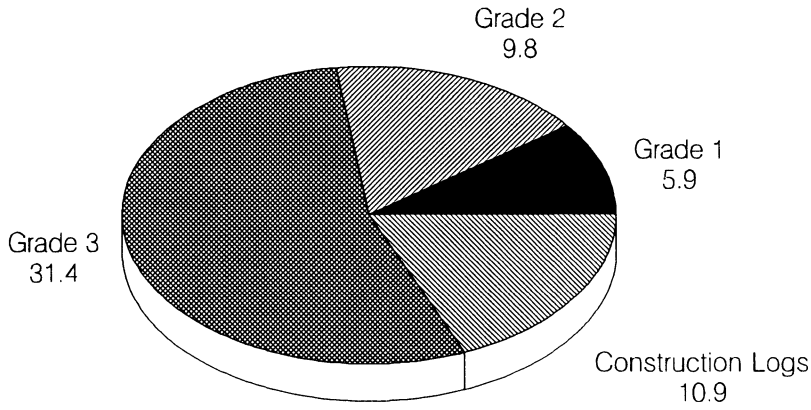
Dead trees recorded in the 1991 VHTHS show very low levels of mortality since 1986 (Figure 13) (Dept. of Forests, Parks and Recreation, 1993). Regional data from New England shows similar low mortality in oak (Brooks et al, 1991).[33]

Overall, oak was in fair to good condition in 1991. Moderately high percentages of trees had healthy crowns and few major stress agents were detected on oak this year. With decreasing populations of gypsy moths, improvements in the condition of oak is anticipated for the near future.



Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 28. Red Oak Sawtimber Log Grades, 1983. The quality of potential red oak sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.



Volumes in Millions of Board Feet
From: Frieswyk & Malley, 1985

Figure 29. White Oak Sawtimber Log Grades, 1983. The quality of potential white oak sawtimber logs in Vermont forests as depicted by 4 log gradings: Grade 1 (highest quality wood), Grade 2, Grade 3, and Construction Logs (lowest quality wood), showing the amount of wood classified in each grade category.

SUMMARY OF FOREST HEALTH

*H*ealth evaluations were conducted on 10 tree species in Vermont forest health plots. Seven of the species had greater than 90% of trees rated as healthy and were therefore considered in good condition: sugar maple, red maple, white ash, balsam fir, red spruce, white pine and paper birch. The remaining three species had 80 to 90% of trees rated as healthy and the species was therefore considered in fair condition: beech, yellow birch and oak. Hemlock was evaluated for stress agents in 1991, but too few individuals are included in our forest health plots to make an evaluation of its overall condition statewide.

SUGAR MAPLE

Sugar maples experienced lower stress with favorable growing conditions in 1991, which resulted in good crown condition. This year sugar maples in Vermont's forests can be considered generally healthy.

BEECH

Beech tree condition was fair in 1991, but had improved over the last 5 years. However, due to the persistence of beech stress agents, the health of beech will continue to be of concern.

YELLOW BIRCH

Yellow Birch in Vermont is in fair condition. Moderately high percentages of crowns are in a healthy condition, but stress from repeated years of defoliation by birch insects may present problems to future conditions of this tree species.

RED MAPLE

The health of red maple in 1991 was good. Dry summer conditions may have posed some stress to trees with shallow root systems, but otherwise, few stressors affected red maple this year.

WHITE ASH

Our survey results found white ash to be in a generally healthy condition this year. Some stress from ash yellows disease was evident in certain locations, but otherwise, 1991 had few stressors and favorable growing conditions for ash.

BALSAM FIR

Our surveys showed that balsam fir was in a healthy condition in 1991. There are small geographical areas where high elevation weather extremes are stressing trees, but the majority of the balsam fir resource showed little sign of stress this year.

RED SPRUCE

The condition of red spruce in Vermont was good in 1991. Environmental stress on red spruce at high elevations continues to be of concern, but otherwise, little stress on this species was detected this year.

WHITE PINE

Vermont white pine was in good condition in 1991. No major stress agents were detected this year, but white pine weevils continue to adversely affect the quality of our white pine timber resource.

PAPER BIRCH

Our survey results indicated that paper birch was in generally healthy condition in 1991, although repeated years of defoliation by birch insect pests does pose a potential threat to the future health of this species.

OAK

Oak was in fair to good condition in 1991. Moderately high percentages of trees had healthy crowns and few major stress agents were detected on oak this year. With decreasing populations of gypsy moths, improvements in the condition of oak is anticipated for the near future.

ENDNOTES REFERENCED IN TEXT

1. A statewide forest inventory is conducted approximately every 10 years. The last inventory was completed in 1983.

2. Sawlog grades are based on USDA Forest Service log grading system.

3. Sugar maple growing stock volume totals 1447.2 million cubic feet (MMCF).

4. Sugar maple sawtimber volume is estimated at 3324.6 million board feet (MMBF).

5. Sugar maple sawtimber log resource classified as Grade 1 quality is estimated at 358.6 thousand board feet (MBF).

6. Sugar maple sawtimber and veneer logs exported to Canada in 1991 was 2562 MBF.

7. VHTHS reported mortality for sugar maple to be 0.5% in 1986 and 2.4% in 1991.

8. Beech comprises 329.7 MMBF of Vermont's growing stock volume.

9. Beech comprises 774.6 MMCF of Vermont's sawtimber resource.

10. Beech Grade 1 sawtimber logs comprise about 42.1 MMBF of Vermont's mature tree resource.

11. Beech exported to other states and countries in the form of sawlogs totaled 146 MBF in 1991.

12. Yellow birch comprises 498.1 MMCF of Vermont's growing stock and 1088.4 MMBF of it's sawtimber volume.

13. Grade 1 yellow birch logs comprise 96.8 MMBF of the total sawtimber resource.

14. Mortality on NFHM plots in New England showed that 11.1% of yellow birch trees were standing dead in 1990.

15. Red maple growing stock was 605.8 MMCF and sawtimber was 1092.9 MMBF in Vermont's forests during the last forest inventory.

16. Red maple Grade 1 logs comprised 88.9 MMBF of sawtimber volumes in Vermont's forest.

17. Regional mortality of red maple under the NFHM program showed that 4.5% of trees were standing dead on the New England plots in 1990.

18. White ash growing stock volume is estimated at 273.8 MMCF.

19. White ash sawtimber volume is estimated at 583.4 MMBF.

20. White ash Grade 1 logs comprise 139.8 MMBF of the total sawtimber resource.

21. Balsam fir growing stock volume is estimated at 353.6 MMCF.

22. Balsam fir sawtimber volume comprises 665.3 MMBF of Vermont's forest resource.

23. Red spruce sawtimber and growing stock volumes comprise 1,177.9 MMBF and 482.3 MMCF of Vermont's forest resource.

24. White pine growing stock and sawtimber volumes are estimated at 448.9 MMCF and 1404.3 MMBF, respectively.

25. Hemlock comprises 520.1 MMCF of growing stock and 1421.7 MMBF of sawtimber volumes in Vermont's forests.

26. Paper birch growing stock volume is 411.7 MMCF and sawtimber volume is 477.1 MMBF in Vermont.

27. Grade 1 paper birch sawtimber logs comprise 29.3 MMBF in Vermont's forests.

28. Regional paper birch mortality recorded under the NFHM program showed 10.3% of trees were standing dead (old and recently dead).

29. Red oak comprised 552.1 MMCF of growing stock volume and 552.1 MMBF of sawtimber trees in Vermont's forests.

30. Red oak Grade 1 logs comprise 145.5 MMBF of Vermont's sawtimber size trees.

31. Vermont forests are comprised of 23.5 MMCF of growing stock volume and 58.0 MMBF of sawtimber in white oak.

32. Grade 1 white oak logs quality in Vermont's forests is estimated at 5.9 MMBF.

33. Region wide, the NFHM data show that 1.0% of red oak trees were dead in 1990.

REFERENCE CITED

Brooks, R. T., M.M. Weeks and W. Burkman. 1991. Forest Health Monitoring: New England, 1990 (Summary Report). USDA Forest Service, Northeastern Area, NE-INF-94-91.

Dowsett, S. E., R. L. Anderson, and W. H. Hoffard. 1991. Review of selected articles on the ozone sensitivity and associated symptoms for plants commonly found in the forest environment, pp 1-19; IN Bioindicator Ozone Surveys, USDA Forest Service Region 8, Forest Pest Management, Asheville, N.C.

Eagar, C. and M.B. Adams (eds.). 1992. Ecology and Decline of Red Spruce in the Eastern United States. Ecological Studies, Analysis and Synthesis. Vol. 96. Springer-Verlag, N.Y. 417 pp.

Eagar, C., M.Miller-Weeks, A.J.R. Gillespie and W. Burkman. 1992. Forest Health Monitoring in the Northeast, 1991 (Summary Report). USDA Forest Service, Northeastern Area, NE/NA-INF-115-92.

Frieswyk, T. S. and A.M. Malley. 1985. Forest Statistics for Vermont - 1973 and 1983. Resour. Bull. NE 87. Radnor, PA: U.S. Dept. of Agr., Forest Service; 1985. 102 pp.

O'Brien, J.T. 1990. Evaluation of ozone damage to vegetation on the Lye Brook Wilderness in 1989; a survey report. USDA-Forest Service, PO Box 640, Durham, NH 03824. 11pp.

O'Brien, J.T. 1991. Evaluation of ozone damage to vegetation on the Lye Brook Wilderness in 1990; a survey report. USDA - Forest Service, PO Box 640, Durham, NH 03824. 11pp.

Parker, B.L., K.E. McGrath, S. Moulton, and H.B. Teillon. 1989. History of the Major Forest Insect Pests in Vermont. A joint VT Agr. Exp. Station and State of VT publication. RR 57. Univ. VT, Burlington 05405. 32 pp.

Vt. Dept. of Agriculture, Food and Markets. 1991. Vermont Maple Syrup Production Statistics (personal communications). Vt. Dept. of Agriculture, Food and Markets, 116 State St., Montpelier, VT 05620.

Vt. Dept. of Environmental Conservation. 1992. Vermont Acid Precipitation Monitoring Program: 1983-1991. Vt. Dept. of Environmental Conservation, Water Quality Section, 103 South Main St., Waterbury, VT 05671.

Vt. Dept. of Fish and Wildlife, 1991. Vermont fishing and hunting statistics (personal communications). Vermont Department of F&W, 103 South Main Street, Waterbury, VT 05671

Vt. Dept. of Forests, Parks and Recreation. 1993. Vermont Hardwood Tree Health Survey in 1991 Compared to 1986. VT Dept. Forests, Parks and Recreation, 103 So. Main St., Waterbury, VT 05671.

Vt Dept. of Forests, Parks and Recreation, 1991a. 1991 Vermont Forest Resource Harvest Report. VT Dept. of Forests, Parks and Recreation, 103 So. Main St., Waterbury, VT 05671.

Vt. Dept. of Forests, Parks and Recreation. 1991b. Vermont Monitoring Cooperative Annual Report for 1991. S.H. Wilmot and T.D. Scherbatskoy (eds.). VT Dept. Forests, Parks and Recreation, 103 So. Main St., Waterbury, VT 05671.

Vt. Dept. of Forests, Parks and Recreation. 1991c. Vermont Insect and Disease Conditions Report: 1991. VT Dept. Forests, Parks and Recreation, 103 So. Main St., Waterbury, VT 05671.

ABBREVIATIONS

NAMP = North American Maple Project
NFHM = National Forest Health Monitoring
MBF = thousands of board feet
MMBF = millions of board feet
MMCF = millions of cubic feet
VHTHS = Vermont Hardwood Tree Health Survey

APPENDIX A

PLOT LOCATIONS AND PROGRAM DESCRIPTIONS

NORTH AMERICAN MAPLE PROJECT began in 1988 out of regional concern about the health of sugar maple trees. This is an international program that includes 4 Canadian Provinces and 7 U.S. States. The purpose of this program is to monitor sugar maple health and determine if pollution and/or tapping trees for maple syrup production are adversely affecting their condition. All cooperators use the same plot design, methods of data collection, and the data is analyzed at one central location. Vermont has 29 NAMP plots, and hopes to expand this network in future years.

NATIONAL FOREST HEALTH MONITORING PROGRAM began in 1990 in New England. The purpose of this program is to monitor the condition of our forests over time to determine trends in condition, determine potential forest stressors and determine the relationship between stressors and changes in forest condition. In Vermont there are 35 plots in this system, but only 24 are currently forested.

VERMONT HARDWOOD TREE HEALTH SURVEY is a state-specific survey which includes both photographic and ground evaluations. It began in 1985/86 and is repeated on a 5 year basis. There are 175 photo points and 74 ground survey plots where tree health data are collected.

VERMONT MONITORING COOPERATIVE is Vermont's Intensive Forest Ecosystem Monitoring and Research Program. It began in 1991 to look at forests as a whole. At its Mount Mansfield site, the VMC joins together a variety of experts to look at forest conditions, weather, air quality, wildlife, streams, and other factors at the same location. This approach will help us learn basic information about our forests that will aid in planning for the future in light of changes in our environment.

AERIAL SURVEY PROCEDURE

Annual flights over the state are performed by the Vermont Forestry Division to determine areas where tree damage or defoliation is present. Locations and extent of damage are recorded. Ground verifications are made to discern the cause for noticed damage. The information is compiled statewide and reported in the annual Vermont Insect and Disease Conditions Report. This forms the basis for our knowledge on annual stresses occurring to our forests.

APPENDIX B

Summary of results on the trend in tree health, by species, comparing regional and Vermont data.

SUGAR MAPLE

	% OF TREES HEALTHY				
	REGIONAL PLOT SYSTEM		VERMONT PLOT SYSTEM		
YEAR	NAMP	NFHM	VHTHS	VT NAMP	VT NFHM
1991	95.4	98.2	93	94	100
1990	95.2	97.1		93	98
1989	93.8			93	
1988	91			82	
1986			81		

AMERICAN BEECH

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VHTHS
1991	90	82
1990	87	
1986		54

YELLOW BIRCH

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VHTHS
1991	98	88
1990	97	
1986		70

RED MAPLE

	% OF TREES HEALTHY		
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM	
YEAR	NFHM	VHTHS	VT NFHM
1991	96	91	97
1990	94		99
1986		79	

WHITE ASH

	% OF TREES HEALTHY		
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM	
YEAR	NFHM	VHTHS	VT NAMP
1991	95	98	91
1990	96	98	
1989			94
1986		86	

BALSAM FIR

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VT NFHM
1991	99	100
1990	99	100

RED SPRUCE

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VT NFHM
1991	100	100
1990	99	95

WHITE PINE

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VT NFHM
1991	100	100
1990	99	99

HEMLOCK

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	*
1991	98	--
1990	96	--

* = Too few hemlocks represented in our forest health plot system in Vermont.

OAK

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VHTHS
1991	98	88
1990	99	
1986		81

PAPER BIRCH

	% OF TREES HEALTHY	
	REGIONAL PLOT SYSTEM	VERMONT PLOT SYSTEM
YEAR	NFHM	VHTHS
1991	94	96
1990	96	
1986		88